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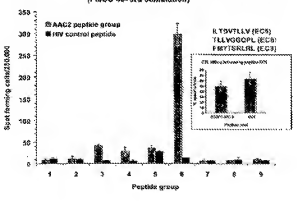
(54) Title: PREVENTION AND TREATMENT OF DISEASE USING ANGIOGENESIS-AND/OR TUMOR ANTIGENS



(57) Abstract: The present invention relates to the use of nucleic acids, polypeptides, and/or derivatives thereof for preventing and/or treating diseases. In particular, the invention relates to the prevention and/or treatment of cancer.

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Prevention and Treatment of Disease Using Angiogenesis- and / or Tumor Antigens

FIELD OF THE INVENTION

The present invention relates to the use of nucleic acids, polypeptides, and / or derivatives thereof for preventing and / or treating diseases. In particular, the invention relates to the prevention and / or treatment of cancer.

BACKGROUND OF THE INVENTION

Diseases and processes known to be associated with angiogenesis include, for example, cancer, inflammatory bowel disease, keratitis associated with HSV infection, psoriasis, pterygia, autosomal-dominant polycystic kidney disease (ADPKD), and angiogenic eye disease, among others (Timar, et al. *Pathol. Oncol. Res.*, 2001, 7(2): 85-94). Cancers shown to be dependent upon angiogenesis include breast cancer, colorectal cancer, lung cancers such as small cell lung cancer, gastric carcinoma, prostate cancer, ovarian cancer, cervical cancer, bladder cancer, endometrial cancers, hepatocellular carcinoma, skin cancers (i.e., melanoma, and squamous cell carcinoma), sarcomas (i.e., Kaposi's sarcoma, leiomyosarcoma), adult soft tissue sarcomas, blood cancers such as leukemia and multiple myeloma, as well as nervous tissue cancers (i.e., astrocytoma, malignant mesothelioma, and neuroblastoma), among others.

Typical approaches to anti-angiogenic therapy target endothelial cell (EC) proliferation, survival, and primitive vessel formation in small *in situ* neoplasms and metastatic lesions without adversely affecting mature vascular tissue elsewhere in the body. Angiogenesis is a genetically stable process and neoplastic transformation of EC is a very rare occurrence. Thus, the genetic heterogeneity and instability inherent in the tumor cells is not a limiting factor in strategies aimed at inhibiting tumor angiogenesis as form of cancer treatment. These characteristics make angiogenesis one of 'unifying' principles in cancer biology and a therapeutic target for virtually all types of solid tumors. Moreover, recent evidence suggests that leukemia requires angiogenesis to support pockets of rapidly dividing leukemic cells in the bone marrow.

A number of anti-angiogenic therapies have been developed. Several clinical trials have taken place and / or are ongoing including anti-VEGF and anti-$\alpha_v\beta_3$ monoclonal antibodies that

interfere with ligands promoting angiogenesis; tyrosine kinase inhibitors PTK787 and ZK2284 that block signals downstream of VEGFR-2; suppression of MMP function using synthetic inhibitors (i.e., Marimastat and AG3340); the use of naturally occurring cytokines such as IFN-α to inhibit of VEGF and bFGF secretion; inhibition of EC proliferation through small drugs and fungal toxins (i.e., TNP-470) and a fragment of anti-thrombin III; thalidomide and Celebrex used to inhibit cyclo-oxygenase activity that promotes angiogenesis; the injection of natural inhibitors of angiogenesis derived from collagen XVIII (endostatin) and plasminogen (angiostatin) and troponin I, and "metronomic therapy" involving the application of traditional cancer chemotherapeutic drugs (e,g, cyclophosphamide) in a low dose continuous fashion. A common difficulty in these trials has been either toxicity or lack of clinical effectiveness.

The feasibility of a vaccine approach at inhibiting tumor angiogenesis has recently been demonstrated by a number of groups. One group of studies has targeted the VEGF-VEGFR-2 system needed for EC proliferation and invasion into surrounding stromal tissue, while another has inhibited the bFGF-EGF pathway. In all, there have been six published or presented studies in this area described below.

Passive monoclonal antibody infusion therapies have been used to try to block the VEGF-VEGFR-2 pathway with partial success. The VEGF-VEGFR-2 signaling pathway is one of the most critical pathways involved in angiogenesis. In the first vaccination approach, xenogeneic fixed human EC were used to induce an immune response in tumor-bearing mice. This resulted in anti-VEGFR-2 and anti-$\alpha_v\beta_3$ integrin antibodies being detected in the serum correlating to the inhibition of the growth of a variety of subcutaneous tumors, including breast tumors and fibrosarcoma. DNA vaccination using a plasmid encoding *Xenopus* VEGF has also been used to inhibit solid tumor growth through the generation of anti-VEGF antibodies. A dendritic cell-based vaccine against the VEGF-VEGFR-2 system has also demonstrated a 60% reduction in metastases in a Lewis lung carcinoma model.

The bFGF-EGF pathway has also been targeted. A liposomal FGF-2 peptide vaccine was shown to potently block angiogenesis in a gelfoam sponge model of angiogenesis *in vivo* and inhibited metastasis of B16BL6 melanoma by up to 90% and up to 60% in the Lewis lung carcinoma model.

A cDNA encoding the transmembrane protein HP59 was found to be specifically expressed in tumor vasculature by immunohistochemistry (IHC). Mice immunized with HP59 and SP55 (murine orthologue of HP59) peptides showed significant attenuation of tumor growth. IHC performed after vaccination and tumor challenge showed an absence of both HP59 and CD34 positive vessels in the tumors.

An indirect immunotherapeutic strategy for inhibiting tumor angiogenesis has also been described. Tissue factor (TF) was targeted by constructing a fusion protein between the TF ligand, factor VII (fVII) and the effector domain of IgG1 Fc. An adenoviral construct encoding fVII-Fc was injected into tumors resulting in the secretion of the fusion protein and inhibition of tumor growth.

Gene profiling efforts have recently identified genes expressed EC during angiogenesis. Several genes encoding tumor endothelial markers (TEM) overexpressed in tumor vasculature have been identified. In that study, RNA was isolated from EC purified from collagenase-digested human colorectal tumor tissue using immuno-magnetic beads sorting. Nine genes, TEM1-TEM9, were found to be specifically over-expressed in tumor EC and not expressed in normal EC or EC cell lines. As such, the proteins expressed from these genes may be useful targets for immunotherapy of angiogenesis-related diseases.

There is a need in the art for reagents and methodologies useful in stimulating an immune response to prevent or treat angiogenesis-related diseases. The present inventions provides such reagents and methodologies which overcome many of the difficulties encountered by others in attempting to treat angiogenesis-related diseases such as cancer.

SUMMARY OF THE INVENTION

The present invention provides an immunogenic target prevent and / or treat a disease, such as cancer. In particular, the immunogenic target is a tumor antigen ("TA") or an angiogenesis-associated antigen ("AA"). In one embodiment, the TA and / or AA are administered to a patient as a nucleic acid contained within a plasmid or other delivery vector, such as a recombinant virus or as a polypeptide, or derivative thereof. The TA and / or AA may also be administered in combination with an immune stimulator, such as a co-stimulatory

molecule or adjuvant, and / or together with vaccines for other tumor-related antigens. Screening assays and compounds identified thereby are also provided.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1. A. Nucleotide sequences of AAC2-1 and AAC2-2. **B.** Alignment of predicted amino acid sequence of AAC2-1 and AAC2-2. Missing nucleotides or amino acids are indicated by a "*". Differences between sequences are underlined.

Figure 2. A. Human lymphocytes differentiate into effector cells secreting IFN-γ in response to peptides derived from the AAC2-2 protein. T cells were stimulated with the groups of peptides shown in Table III (groups 1-9). After three rounds of stimulation, the lymphocytes were analyzed for peptide-specific IFN-γ production by ELISPOT. **B.** The graph in the inset shows that activated cells stimulated by peptide Group #6 are capable of antigen-specific CTL activity killing peptide loaded T2 target cells. Peptide EC5 elicits dominant activity in inducing both CTL activity and IFN-γ secretion.

Figure 3. Murine T cells from HLA-A2-Kb transgenic mice recognize and secrete IFN-γ in response to DNA immunization with a human AAC2-2-encoding DNA plasmid. Spleen cells from pEF6-hAAC2-2-immunized mice were re-stimulated with the groups of peptides shown (**Table III**). After six days, the cells were harvested and tested for IFN-γ secretion in response to each respective peptide group or a control HLA-A2-binding 9-mer HIV peptide. ELISPOT plates were incubated over- night and developed. Each group responded with high levels of IFN-γ production (over 250 spots) in response to PMA and ionomycin used as a positive control. One of the highly reactive peptide groups (group 6) is also recognized by human lymphocytes from the HLA-A-0201^{+} donors tested so far.

Figure 4. DNA vaccination with a gene encoding human AAC2-2 completely abrogates the growth of implanted B16F10 melanoma cells. This effect is not due to a non-specific immune response as shown by the inability of plasmid encoding flu-NP protein and the human flk1 (VEGFR-2) to prevent tumor growth.

Figure 5. Survival of mice after implantation of B16F10 melanoma cells into C57BL/6 mice showing the ability of DNA vaccination with a human AAC2-2 vector to completely protect

against the effects of tumor growth. This protective effect is antigen-specific and can not be elicited through vaccination with other genes.

Figure 6. T lymphocytes from C57BL/6 mice exhibit effector cell activity and secrete IFN-γ in response to peptides of human AAC2-2 following DNA vaccination with the pEF6-hAAC2-2 expression plasmid. The peptide groups used in the experiment are the same as those listed in **Table III**, chosen for HLA-A2 binding potential. These peptides can exhibit cross-reactivity on B6 MHC class I. The peptides in group 1 and group 5 induce strong reactivity by C57BL/6 T cells.

DETAILED DESCRIPTION

The present invention provides reagents and methodologies useful for treating and / or preventing angiogenesis-associated diseases. All references cited within this application are incorporated by reference.

In one embodiment, the present invention relates to the induction or enhancement of an immune response against one or more angiogenesis-associated antigens ("AA") to prevent and / or treat an angiogenesis-related disease. In certain embodiments, one or more AAs may be combined with one or more tumor antigens ("TA") to prevent or treat cancer. In preferred embodiments, the immune response results from expression of an AA or TA in a host cell following administration of a nucleic acid vector encoding the tumor antigen or the tumor antigen itself in the form of a peptide or polypeptide, for example.

As used herein, an "antigen" is a molecule (such as a polypeptide) or a portion thereof that produces an immune response in a host to whom the antigen has been administered. The immune response may include the production of antibodies that bind to at least one epitope of the antigen and / or the generation of a cellular immune response against cells expressing an epitope of the antigen. The response may be an enhancement of a current immune response by, for example, causing increased antibody production, production of antibodies with increased affinity for the antigen, or an increased cellular response (i.e., increased T cells). An antigen that produces an immune response may alternatively be referred to as being immunogenic or as an immunogen. In describing the present invention, AAs and TAs may at times collectively, or in the alternative, be referred to as an "immunogenic target".

An AA is an immunogenic molecule (i.e., peptide, polypeptide) associated with cells involved in the induction and / or continued development of blood vessels. For example, an AA may be expressed on an endothelial cell ("EC"), which is a primary structural component of blood vessels. Where the angiogenesis-related disease is cancer, it is preferred that that the AA be found within or near blood vessels that supply a tumor. Immunization of a patient against an AA preferably results in an anti-AA immune response whereby angiogenic processes that occur near or within tumors are prevented and / or inhibited.

Exemplary AAs include, for example, vascular endothelial growth factor (i.e., VEGF; Bernardini, et al. *J. Urol.*, 2001, 166(4): 1275-9; Starnes, et al. *J. Thorac. Cardiovasc. Surg.*, 2001, 122(3): 518-23), the VEGF receptor (i.e., VEGF-R, flk-1/KDR; Starnes, et al. *J. Thorac. Cardiovasc. Surg.*, 2001, 122(3): 518-23), EPH receptors (i.e., EPHA2; Gerety, et al. 1999, *Cell*, 4: 403-414), epidermal growth factor receptor (i.e., EGFR; Ciardeillo, et al. Clin. Cancer Res., 2001, 7(10): 2958-70), basic fibroblast growth factor (i.e., bFGF; Davidson, et al. Clin. Exp. Metastasis 2000,18(6): 501-7; Poon, et al. Am J. Surg., 2001, 182(3):298-304), platelet-derived cell growth factor (i.e., PDGF-B), platelet-derived endothelial cell growth factor (PD-ECGF; Hong, et al. J. Mol. Med., 2001, 8(2):141-8), transforming growth factors (i.e., TGF-α; Hong, et al. J. Mol. Med., 2001, 8(2):141-8), endoglin (Balza, et al. *Int. J. Cancer*, 2001, 94: 579-585), Id proteins (Benezra, R. Trends Cardiovasc. Med., 2001, 11(6):237-41), proteases such as uPA, uPAR, and matrix metalloproteinases (MMP-2, MMP-9; Djonov, et al. J. Pathol., 2001, 195(2):147-55), nitric oxide synthase (Am. J. Ophthalmol., 2001, 132(4):551-6), aminopeptidase (Rouslhati, E. Nature Cancer, 2: 84-90, 2002), thrombospondins (i.e., TSP-1, TSP-2; Alvarez, et al. Gynecol. Oncol., 2001, 82(2):273-8; Seki, et al. Int. J. Oncol., 2001, 19(2):305-10), k-*ras* (Zhang, et al. Cancer Res., 2001, 61(16):6050-4), *Wnt* (Zhang, et al. Cancer Res., 2001, 61(16):6050-4), cyclin-dependent kinases (CDKs; Drug Resist. Updat. 2000, 3(2):83-88), microtubules (Timar, et al. 2001. *Path. Oncol. Res.*, 7(2): 85-94), heat shock proteins (i.e., HSP90 (Timar, *supra*)), heparin-binding factors (i.e., heparinase; Gohji, et al. Int. J. Cancer, 2001, 95(5):295-301), synthases (i.e., ATP synthase, thymidilate synthase), collagen receptors, integrins (i.e., $\alpha_v\beta3$, $\alpha_v\beta5$, $\alpha1\beta1$, $\alpha2\beta1$, $\alpha5\beta1$), the surface proteolglycan NG2, AAC2-1 (**Fig. 1**; SEQ ID NOS.: 1 and 2) or AAC2-2 (**Fig. 1**; SEQ ID NOS.:3, 4, and 5), among

others, including "wild-type" (i.e., normally encoded by the genome, naturally-occurring), modified, mutated versions as well as other fragments and derivatives thereof. A preferred AA is AAC2-2. Any of these targets may be suitable in practicing the present invention, either alone or in combination with one another or with other agents.

In certain cases, it may be beneficial to co-immunize patients with both AA and tumor antigens ("TA"). TA includes both tumor-associated antigens (TAAs) and tumor-specific antigens (TSAs), where a cancerous cell is the source of the antigen. A TAA is an antigen that is expressed on the surface of a tumor cell in higher amounts than is observed on normal cells or an antigen that is expressed on normal cells during fetal development. A TSA is an antigen that is unique to tumor cells and is not expressed on normal cells. TA further includes TAAs or TSAs, antigenic fragments thereof, and modified versions that retain their antigenicity.

TAs are typically classified into five categories according to their expression pattern, function, or genetic origin: cancer-testis (CT) antigens (i.e., MAGE, NY-ESO-1); melanocyte differentiation antigens (i.e., Melan A/MART-1, tyrosinase, gp100); mutational antigens (i.e., MUM-1, p53, CDK-4); overexpressed 'self' antigens (i.e., HER-2/neu, p53); and, viral antigens (i.e., HPV, EBV). For the purposes of practicing the present invention, a suitable TA is any TA that induces or enhances an anti-tumor immune response in a host to whom the TA has been administered. Suitable TAs include, for example, gp100 (Cox et al., *Science*, 264:716-719 (1994)), MART-1/Melan A (Kawakami et al., *J. Exp. Med.*, 180:347-352 (1994)), gp75 (TRP-1) (Wang et al., *J. Exp. Med.*, 186:1131-1140 (1996)), tyrosinase (Wolfel et al., *Eur. J. Immunol.*, 24:759-764 (1994); WO 200175117; WO 200175016; WO 200175007), NY-ESO-1 (WO 98/14464; WO 99/18206), melanoma proteoglycan (Hellstrom et al., *J. Immunol.*, 130:1467-1472 (1983)), MAGE family antigens (i.e., MAGE-1, 2,3,4,6, and 12; Van der Bruggen et al., *Science*, 254:1643-1647 (1991); U.S. Pat. Nos. 6,235,525), BAGE family antigens (Boel et al., *Immunity*, 2:167-175 (1995)), GAGE family antigens (i.e., GAGE-1,2; Van den Eynde et al., *J. Exp. Med.*, 182:689-698 (1995); U.S. Pat. No. 6,013,765), RAGE family antigens (i.e., RAGE-1; Gaugler et at., *Immunogenetics*, 44:323-330 (1996); U.S. Pat. No. 5,939,526), N-acetylglucosaminyltransferase-V (Guilloux et at., *J. Exp. Med.*, 183:1173-1183 (1996)), p15 (Robbins et al., *J. Immunol.* 154:5944-5950 (1995)), ß-catenin (Robbins et al., *J. Exp. Med.*,

183:1185-1192 (1996)), MUM-1 (Coulie et al., *Proc. Natl. Acad. Sci.* USA, 92:7976-7980 (1995)), cyclin dependent kinase-4 (CDK4) (Wolfel et al., *Science*, 269:1281-1284 (1995)), p21-*ras* (Fossum et at., *Int. J. Cancer*, 56:40-45 (1994)), BCR-*abl* (Bocchia et al., *Blood*, 85:2680-2684 (1995)), p53 (Theobald et al., *Proc. Natl. Acad. Sci.* USA, 92:11993-11997 (1995)), p185 HER2/neu (erb-B1; Fisk et al., *J. Exp. Med.*, 181:2109-2117 (1995)), epidermal growth factor receptor (EGFR) (Harris et al., Breast Cancer Res. Treat, 29:1-2 (1994)), carcinoembryonic antigens (CEA) (Kwong et al., *J. Natl. Cancer Inst.*, 85:982-990 (1995) U.S. Pat. Nos. 5,756,103; 5,274,087; 5,571,710; 6,071,716; 5,698,530; 6,045,802; EP 263933; EP 346710; and, EP 784483); carcinoma-associated mutated mucins (i.e., MUC-1 gene products; Jerome et al., *J. Immunol.*, 151:1654-1662 (1993)); EBNA gene products of EBV (i.e., EBNA-1; Rickinson et al., *Cancer Surveys*, 13:53-80 (1992)); E7, E6 proteins of human papillomavirus (Ressing et al., *J. Immunol*, 154:5934-5943 (1995)); prostate specific antigen (PSA; Xue et al., *The Prostate*, 30:73-78 (1997)); prostate specific membrane antigen (PSMA; Israeli, et al., *Cancer Res.*, 54:1807-1811 (1994)); idiotypic epitopes or antigens, for example, immunoglobulin idiotypes or T cell receptor idiotypes (Chen et al., *J. Immunol.*, 153:4775-4787 (1994)); KSA (U.S. Patent No. 5,348,887), kinesin 2 (Dietz, et al. Biochem Biophys Res Commun 2000 Sep 7;275(3):731-8), HIP-55, TGFβ-1 anti-apoptotic factor (Toomey, et al. Br J Biomed Sci 2001;58(3):177-83), tumor protein D52 (Bryne J.A., et al., Genomics, 35:523-532 (1996)), H1FT, NY-BR-1 (WO 01/47959), NY-BR-62, NY-BR-75, NY-BR-85, NY-BR-87 and NY-BR-96 (Scanlan, M. Serologic and Bioinformatic Approaches to the Identification of Human Tumor Antigens, in *Cancer Vaccines 2000*, Cancer Research Institute, New York, NY), including "wild-type" (i.e., normally encoded by the genome, naturally-occurring), modified, mutated versions as well as other fragments and derivatives thereof. Any of these TAs may be utilized alone or in combination with one or more other TAs as well as one or more AAs in a co-immunization protocol.

In certain embodiments, a nucleic acid molecule encoding an immunogenic target is utilized. The nucleic acid molecule may comprise or consist of a nucleotide sequence encoding one or more immunogenic targets, or fragments or derivatives thereof, such as that contained in a DNA insert in an ATCC Deposit. The term "nucleic acid sequence" or "nucleic acid molecule"

refers to a DNA or RNA sequence. The term encompasses molecules formed from any of the known base analogs of DNA and RNA such as, but not limited to 4-acetylcytosine, 8-hydroxy-N6-methyladenosine, aziridinyl-cytosine, pseudoisocytosine, 5-(carboxyhydroxylmethyl) uracil, 5-fluorouracil, 5-bromouracil, 5-carboxymethylaminomethyl-2-thiouracil, 5-carboxy-methylaminomethyluracil, dihydrouracil, inosine, N6-iso-pentenyladenine, 1-methyladenine, 1-methylpseudouracil, 1-methylguanine, 1-methylinosine, 2,2-dimethyl-guanine, 2-methyladenine, 2-methylguanine, 3-methylcytosine, 5-methylcytosine, N6-methyladenine, 7-methylguanine, 5-methylaminomethyluracil, 5-methoxyamino-methyl-2-thiouracil, beta-D-mannosylqueosine, 5' -methoxycarbonyl-methyluracil, 5-methoxyuracil, 2-methylthio-N6-isopentenyladenine, uracil-5-oxyacetic acid methylester, uracil-5-oxyacetic acid, oxybutoxosine, pseudouracil, queosine, 2-thiocytosine, 5-methyl-2-thiouracil, 2-thiouracil, 4-thiouracil, 5-methyluracil, N-uracil-5-oxyacetic acid methylester, uracil-5-oxyacetic acid, pseudouracil, queosine, 2-thiocytosine, and 2,6-diaminopurine, among others.

An isolated nucleic acid molecule is one that: 1) is separated from at least about 50 percent of proteins, lipids, carbohydrates, or other materials with which it is naturally found when total nucleic acid is isolated from the source cells; (2) is not be linked to all or a portion of a polynucleotide to which the nucleic acid molecule is linked in nature; (3) is operably linked to a polynucleotide which it is not linked to in nature; and / or, (4) does not occur in nature as part of a larger polynucleotide sequence. Preferably, the isolated nucleic acid molecule of the present invention is substantially free from any other contaminating nucleic acid molecule(s) or other contaminants that are found in its natural environment that would interfere with its use in polypeptide production or its therapeutic, diagnostic, prophylactic or research use. As used herein, the term "naturally occurring" or "native" or "naturally found" when used in connection with biological materials such as nucleic acid molecules, polypeptides, host cells, and the like, refers to materials which are found in nature and are not manipulated by man. Similarly, "non-naturally occurring" or "non-native" as used herein refers to a material that is not found in nature or that has been structurally modified or synthesized by man.

The identity of two or more nucleic acid or polypeptide molecules is determined by comparing the sequences. As known in the art, "identity" means the degree of sequence

relatedness between nucleic acid molecules or polypeptides as determined by the match between the units making up the molecules (i.e., nucleotides or amino acid residues). Identity measures the percent of identical matches between the smaller of two or more sequences with gap alignments (if any) addressed by a particular mathematical model or computer program (i.e., an algorithm). Identity between nucleic acid sequences may also be determined by the ability of the related sequence to hybridize to the nucleic acid sequence or isolated nucleic acid molecule. In defining such sequences, the term "highly stringent conditions" and "moderately stringent conditions" refer to procedures that permit hybridization of nucleic acid strands whose sequences are complementary, and to exclude hybridization of significantly mismatched nucleic acids. Examples of "highly stringent conditions" for hybridization and washing are 0.015 M sodium chloride, 0.0015 M sodium citrate at 65-68°C or 0.015 M sodium chloride, 0.0015 M sodium citrate, and 50% formamide at 42°C. (see, for example, Sambrook, Fritsch & Maniatis, *Molecular Cloning: A Laboratory Manual* (2nd ed., Cold Spring Harbor Laboratory, 1989); Anderson *et al.*, *Nucleic Acid Hybridisation: A Practical Approach* Ch. 4 (IRL Press Limited)). The term "moderately stringent conditions" refers to conditions under which a DNA duplex with a greater degree of base pair mismatching than could occur under "highly stringent conditions" is able to form. Exemplary moderately stringent conditions are 0.015 M sodium chloride, 0.0015 M sodium citrate at 50-65°C or 0.015 M sodium chloride, 0.0015 M sodium citrate, and 20% formamide at 37-50°C. By way of example, moderately stringent conditions of 50°C in 0.015 M sodium ion will allow about a 21% mismatch. During hybridization, other agents may be included in the hybridization and washing buffers for the purpose of reducing non-specific and/or background hybridization. Examples are 0.1% bovine serum albumin, 0.1% polyvinyl-pyrrolidone, 0.1% sodium pyrophosphate, 0.1% sodium dodecylsulfate, $NaDodSO_4$, (SDS), ficoll, Denhardt's solution, sonicated salmon sperm DNA (or another non-complementary DNA), and dextran sulfate, although other suitable agents can also be used. The concentration and types of these additives can be changed without substantially affecting the stringency of the hybridization conditions. Hybridization experiments are usually carried out at pH 6.8-7.4; however, at typical ionic strength conditions, the rate of hybridization is nearly independent of pH.

In preferred embodiments of the present invention, vectors are used to transfer a nucleic acid sequence encoding a polypeptide to a cell. A vector is any molecule used to transfer a nucleic acid sequence to a host cell. In certain cases, an expression vector is utilized. An expression vector is a nucleic acid molecule that is suitable for transformation of a host cell and contains nucleic acid sequences that direct and / or control the expression of the transferred nucleic acid sequences. Expression includes, but is not limited to, processes such as transcription, translation, and splicing, if introns are present. Expression vectors typically comprise one or more flanking sequences operably linked to a heterologous nucleic acid sequence encoding a polypeptide. Flanking sequences may be homologous (i.e., from the same species and / or strain as the host cell), heterologous (i.e., from a species other than the host cell species or strain), hybrid (i.e., a combination of flanking sequences from more than one source), or synthetic, for example.

A flanking sequence is preferably capable of effecting the replication, transcription and / or translation of the coding sequence and is operably linked to a coding sequence. As used herein, the term operably linked refers to a linkage of polynucleotide elements in a functional relationship. For instance, a promoter or enhancer is operably linked to a coding sequence if it affects the transcription of the coding sequence. However, a flanking sequence need not necessarily be contiguous with the coding sequence, so long as it functions correctly. Thus, for example, intervening untranslated yet transcribed sequences can be present between a promoter sequence and the coding sequence and the promoter sequence may still be considered operably linked to the coding sequence. Similarly, an enhancer sequence may be located upstream or downstream from the coding sequence and affect transcription of the sequence.

In certain embodiments, it is preferred that the flanking sequence is a trascriptional regulatory region that drives high-level gene expression in the target cell. The transcriptional regulatory region may comprise, for example, a promoter, enhancer, silencer, repressor element, or combinations thereof. The transcriptional regulatory region may be either constitutive, tissue-specific, cell-type specific (i.e., the region is drives higher levels of transcription in a one type of tissue or cell as compared to another), or regulatable (i.e., responsive to interaction with a compound such as tetracycline). The source of a transcriptional regulatory region may be any

prokaryotic or eukaryotic organism, any vertebrate or invertebrate organism, or any plant, provided that the flanking sequence functions in a cell by causing transcription of a nucleic acid within that cell. A wide variety of transcriptional regulatory regions may be utilized in practicing the present invention.

Suitable transcriptional regulatory regions include the CMV promoter (i.e., the CMV-immediate early promoter); promoters from eukaryotic genes (i.e., the estrogen-inducible chicken ovalbumin gene, the interferon genes, the gluco-corticoid-inducible tyrosine aminotransferase gene, and the thymidine kinase gene); and the major early and late adenovirus gene promoters; the SV40 early promoter region (Bernoist and Chambon, 1981, *Nature* 290:304-10); the promoter contained in the 3' long terminal repeat (LTR) of Rous sarcoma virus (RSV) (Yamamoto, *et al.*, 1980, *Cell* 22:787-97); the herpes simplex virus thymidine kinase (HSV-TK) promoter (Wagner *et al.*, 1981, *Proc. Natl. Acad. Sci. U.S.A.* 78:1444-45); the regulatory sequences of the metallothionine gene (Brinster *et al.*, 1982, *Nature* 296:39-42); prokaryotic expression vectors such as the beta-lactamase promoter (Villa-Kamaroff *et al.*, 1978, *Proc. Natl. Acad. Sci. U.S.A.*, 75:3727-31); or the tac promoter (DeBoer *et al.*, 1983, *Proc. Natl. Acad. Sci. U.S.A.*, 80:21-25). Tissue- and / or cell-type specific transcriptional control regions include, for example, the elastase I gene control region which is active in pancreatic acinar cells (Swift *et al.*, 1984, *Cell* 38:639-46; Ornitz *et al.*, 1986, *Cold Spring Harbor Symp. Quant. Biol.* 50:399-409 (1986); MacDonald, 1987, *Hepatology* 7:425-515); the insulin gene control region which is active in pancreatic beta cells (Hanahan, 1985, *Nature* 315:115-22); the immunoglobulin gene control region which is active in lymphoid cells (Grosschedl *et al.*, 1984, *Cell* 38:647-58; Adames *et al.*, 1985, *Nature* 318:533-38; Alexander *et al.*, 1987, *Mol. Cell. Biol.*, 7:1436-44); the mouse mammary tumor virus control region in testicular, breast, lymphoid and mast cells (Leder *et al.*, 1986, *Cell* 45:485-95); the albumin gene control region in liver (Pinkert *et al.*, 1987, *Genes and Devel.* 1:268-76); the alpha-feto-protein gene control region in liver (Krumlauf *et al.*, 1985, *Mol. Cell. Biol.*, 5:1639-48; Hammer *et al.*, 1987, *Science* 235:53-58); the alpha 1-antitrypsin gene control region in liver (Kelsey *et al.*, 1987, *Genes and Devel.* 1:161-71); the beta-globin gene control region in myeloid cells (Mogram *et al.*, 1985, *Nature* 315:338-40; Kollias *et al.*, 1986, *Cell* 46:89-94); the myelin basic protein gene control region in oligodendrocyte cells in the

brain (Readhead *et al.*, 1987, *Cell* 48:703-12); the myosin light chain-2 gene control region in skeletal muscle (Sani, 1985, *Nature* 314:283-86); the gonadotropic releasing hormone gene control region in the hypothalamus (Mason *et al.*, 1986, *Science* 234:1372-78), and the tyrosinase promoter in melanoma cells (Hart, I. Semin Oncol 1996 Feb;23(1):154-8; Siders, et al. Cancer Gene Ther 1998 Sep-Oct;5(5):281-91), among others. Other suitable promoters are known in the art.

As described above, enhancers may also be suitable flanking sequences. Enhancers are cis-acting elements of DNA, usually about 10-300 bp in length, that act on the promoter to increase transcription. Enhancers are typically orientation- and position-independent, having been identified both 5' and 3' to controlled coding sequences. Several enhancer sequences available from mammalian genes are known (i.e., globin, elastase, albumin, alpha-feto-protein and insulin). Similarly, the SV40 enhancer, the cytomegalovirus early promoter enhancer, the polyoma enhancer, and adenovirus enhancers are useful with eukaryotic promoter sequences. While an enhancer may be spliced into the vector at a position 5' or 3' to nucleic acid coding sequence, it is typically located at a site 5' from the promoter. Other suitable enhancers are known in the art, and would be applicable to the present invention.

While preparing reagents of the present invention, cells may need to be transfected or transformed. Transfection refers to the uptake of foreign or exogenous DNA by a cell, and a cell has been transfected when the exogenous DNA has been introduced inside the cell membrane. A number of transfection techniques are well known in the art (i.e., Graham *et al.*, 1973, *Virology* 52:456; Sambrook *et al.*, *Molecular Cloning, A Laboratory Manual* (Cold Spring Harbor Laboratories, 1989); Davis *et al.*, *Basic Methods in Molecular Biology* (Elsevier, 1986); and Chu *et al.*, 1981, *Gene* 13:197). Such techniques can be used to introduce one or more exogenous DNA moieties into suitable host cells.

In certain embodiments, it is preferred that transfection of a cell results in transformation of that cell. A cell is transformed when there is a change in a characteristic of the cell, being transformed when it has been modified to contain a new nucleic acid. Following transfection, the transfected nucleic acid may recombine with that of the cell by physically integrating into a chromosome of the cell, may be maintained transiently as an episomal element without being

replicated, or may replicate independently as a plasmid. A cell is stably transformed when the nucleic acid is replicated with the division of the cell.

The present invention further provides isolated immunogenic targets in polypeptide form. A polypeptide is considered isolated where it: (1) has been separated from at least about 50 percent of polynucleotides, lipids, carbohydrates, or other materials with which it is naturally found when isolated from the source cell; (2) is not linked (by covalent or noncovalent interaction) to all or a portion of a polypeptide to which the "isolated polypeptide" is linked in nature; (3) is operably linked (by covalent or noncovalent interaction) to a polypeptide with which it is not linked in nature; or, (4) does not occur in nature. Preferably, the isolated polypeptide is substantially free from any other contaminating polypeptides or other contaminants that are found in its natural environment that would interfere with its therapeutic, diagnostic, prophylactic or research use.

Immunogenic target polypeptides may be mature polypeptides, as defined herein, and may or may not have an amino terminal methionine residue, depending on the method by which they are prepared. Further contemplated are related polypeptides such as, for example, fragments, variants (i.e., allelic, splice), orthologs, homologues, and derivatives, for example, that possess at least one characteristic or activity (i.e., activity, antigenicity) of the immunogenic target. Also related are peptides, which refers to a series of contiguous amino acid residues having a sequence corresponding to at least a portion of the polypeptide from which its sequence is derived. In preferred embodiments, the peptide comprises about 5-10 amino acids, 10-15 amino acids, 15-20 amino acids, 20-30 amino acids, or 30-50 amino acids. In a more preferred embodiment, a peptide comprises 9-12 amino acids, suitable for presentation upon Class I MHC molecules, for example.

A fragment of a nucleic acid or polypeptide comprises a truncation of the sequence (i.e., nucleic acid or polypeptide) at the amino terminus (with or without a leader sequence) and / or the carboxy terminus. Fragments may also include variants (i.e., allelic, splice), orthologs, homologues, and other variants having one or more amino acid additions or substitutions or internal deletions as compared to the parental sequence. In preferred embodiments, truncations and/or deletions comprise about 10 amino acids, 20 amino acids, 30 amino acids, 40 amino

acids, 50 amino acids, or more. The polypeptide fragments so produced will comprise about 10 amino acids, 25 amino acids, 30 amino acids, 40 amino acids, 50 amino acids, 60 amino acids, 70 amino acids, or more. Such polypeptide fragments may optionally comprise an amino terminal methionine residue. It will be appreciated that such fragments can be used, for example, to generate antibodies or cellular immune responses to immunogenic target polypeptides.

A variant is a sequence having one or more sequence substitutions, deletions, and/or additions as compared to the subject sequence. Variants may be naturally occurring or artificially constructed. Such variants may be prepared from the corresponding nucleic acid molecules. In preferred embodiments, the variants have from 1 to 3, or from 1 to 5, or from 1 to 10, or from 1 to 15, or from 1 to 20, or from 1 to 25, or from 1 to 30, or from 1 to 40, or from 1 to 50, or more than 50 amino acid substitutions, insertions, additions and/or deletions.

An allelic variant is one of several possible naturally-occurring alternate forms of a gene occupying a given locus on a chromosome of an organism or a population of organisms. A splice variant is a polypeptide generated from one of several RNA transcript resulting from splicing of a primary transcript. An ortholog is a similar nucleic acid or polypeptide sequence from another species. For example, the mouse and human versions of an immunogenic target polypeptide may be considered orthologs of each other. A derivative of a sequence is one that is derived from a parental sequence those sequences having substitutions, additions, deletions, or chemically modified variants. Variants may also include fusion proteins, which refers to the fusion of one or more first sequences (such as a peptide) at the amino or carboxy terminus of at least one other sequence (such as a heterologous peptide).

"Similarity" is a concept related to identity, except that similarity refers to a measure of relatedness which includes both identical matches and conservative substitution matches. If two polypeptide sequences have, for example, 10/20 identical amino acids, and the remainder are all non-conservative substitutions, then the percent identity and similarity would both be 50%. If in the same example, there are five more positions where there are conservative substitutions, then the percent identity remains 50%, but the percent similarity would be 75% (15/20). Therefore, in cases where there are conservative substitutions, the percent similarity between two polypeptides will be higher than the percent identity between those two polypeptides.

Substitutions may be conservative, or non-conservative, or any combination thereof. Conservative amino acid modifications to the sequence of a polypeptide (and the corresponding modifications to the encoding nucleotides) may produce polypeptides having functional and chemical characteristics similar to those of a parental polypeptide. For example, a "conservative amino acid substitution" may involve a substitution of a native amino acid residue with a non-native residue such that there is little or no effect on the size, polarity, charge, hydrophobicity, or hydrophilicity of the amino acid residue at that position and, in particlar, does not result in decreased immunogenicity. Suitable conservative amino acid substitutions are shown in **Table I**.

Table I

Original Residues	Exemplary Substitutions	Preferred Substitutions
Ala	Val, Leu, Ile	Val
Arg	Lys, Gln, Asn	Lys
Asn	Gln	Gln
Asp	Glu	Glu
Cys	Ser, Ala	Ser
Gln	Asn	Asn
Glu	Asp	Asp
Gly	Pro, Ala	Ala
His	Asn, Gln, Lys, Arg	Arg
Ile	Leu, Val, Met, Ala, Phe, Norleucine	Leu
Leu	Norleucine, Ile, Val, Met, Ala, Phe	Ile
Lys	Arg, 1,4 Diamino-butyric Acid, Gln, Asn	Arg
Met	Leu, Phe, Ile	Leu
Phe	Leu, Val, Ile, Ala, Tyr	Leu
Pro	Ala	Gly
Ser	Thr, Ala, Cys	Thr
Thr	Ser	Ser
Trp	Tyr, Phe	Tyr
Tyr	Trp, Phe, Thr, Ser	Phe
Val	Ile, Met, Leu, Phe, Ala, Norleucine	Leu

A skilled artisan will be able to determine suitable variants of polypeptide using well-known techniques. For identifying suitable areas of the molecule that may be changed without destroying biological activity (i.e., MHC binding, immunogenicity), one skilled in the art may target areas not believed to be important for that activity. For example, when similar

polypeptides with similar activities from the same species or from other species are known, one skilled in the art may compare the amino acid sequence of a polypeptide to such similar polypeptides. By performing such analyses, one can identify residues and portions of the molecules that are conserved among similar polypeptides. It will be appreciated that changes in areas of the molecule that are not conserved relative to such similar polypeptides would be less likely to adversely affect the biological activity and/or structure of a polypeptide. Similarly, the residues required for binding to MHC are known, and may be modified to improve binding. However, modifications resulting in decreased binding to MHC will not be appropriate in most situations. One skilled in the art would also know that, even in relatively conserved regions, one may substitute chemically similar amino acids for the naturally occurring residues while retaining activity. Therefore, even areas that may be important for biological activity or for structure may be subject to conservative amino acid substitutions without destroying the biological activity or without adversely affecting the polypeptide structure.

Other preferred polypeptide variants include glycosylation variants wherein the number and/or type of glycosylation sites have been altered compared to the subject amino acid sequence. In one embodiment, polypeptide variants comprise a greater or a lesser number of N-linked glycosylation sites than the subject amino acid sequence. An N-linked glycosylation site is characterized by the sequence Asn-X-Ser or Asn-X-Thr, wherein the amino acid residue designated as X may be any amino acid residue except proline. The substitution of amino acid residues to create this sequence provides a potential new site for the addition of an N-linked carbohydrate chain. Alternatively, substitutions that eliminate this sequence will remove an existing N-linked carbohydrate chain. Also provided is a rearrangement of N-linked carbohydrate chains wherein one or more N-linked glycosylation sites (typically those that are naturally occurring) are eliminated and one or more new N-linked sites are created. To affect O-linked glycosylation of a polypeptide, one would modify serine and / or threonine residues.

Additional preferred variants include cysteine variants, wherein one or more cysteine residues are deleted or substituted with another amino acid (*e.g.*, serine) as compared to the subject amino acid sequence set. Cysteine variants are useful when polypeptides must be refolded into a biologically active conformation such as after the isolation of insoluble inclusion

bodies. Cysteine variants generally have fewer cysteine residues than the native protein, and typically have an even number to minimize interactions resulting from unpaired cysteines.

In other embodiments, the isolated polypeptides of the current invention include fusion polypeptide segments that assist in purification of the polypeptides. Fusions can be made either at the amino terminus or at the carboxy terminus of the subject polypeptide variant thereof. Fusions may be direct with no linker or adapter molecule or may be through a linker or adapter molecule. A linker or adapter molecule may be one or more amino acid residues, typically from about 20 to about 50 amino acid residues. A linker or adapter molecule may also be designed with a cleavage site for a DNA restriction endonuclease or for a protease to allow for the separation of the fused moieties. It will be appreciated that once constructed, the fusion polypeptides can be derivatized according to the methods described herein. Suitable fusion segments include, among others, metal binding domains (e.g., a poly-histidine segment), immunoglobulin binding domains (i.e., Protein A, Protein G, T cell, B cell, Fc receptor, or complement protein antibody-binding domains), sugar binding domains (e.g., a maltose binding domain), and/or a "tag" domain (i.e., at least a portion of α-galactosidase, a strep tag peptide, a T7 tag peptide, a FLAG peptide, or other domains that can be purified using compounds that bind to the domain, such as monoclonal antibodies). This tag is typically fused to the polypeptide upon expression of the polypeptide, and can serve as a means for affinity purification of the sequence of interest polypeptide from the host cell. Affinity purification can be accomplished, for example, by column chromatography using antibodies against the tag as an affinity matrix. Optionally, the tag can subsequently be removed from the purified sequence of interest polypeptide by various means such as using certain peptidases for cleavage. As described below, fusions may also be made between a TA and a co-stimulatory components such as the chemokines CXC10 (IP-10), CCL7 (MCP-3), or CCL5 (RANTES), for example.

A fusion motif may enhance transport of an immunogenic target to an MHC processing compartment, such as the endoplasmic reticulum. These sequences, referred to as tranduction or transcytosis sequences, include sequences derived from HIV tat (see Kim et al. 1997 J. Immunol. 159:1666), *Drosophila* antennapedia (see Schutze-Redelmeier et al. 1996 J. Immunol. 157:650), or human period-1 protein (hPER1; in particular, SRRHHCRSKAKRSRHH).

In addition, the polypeptide or variant thereof may be fused to a homologous polypeptide to form a homodimer or to a heterologous polypeptide to form a heterodimer. Heterologous peptides and polypeptides include, but are not limited to: an epitope to allow for the detection and/or isolation of a fusion polypeptide; a transmembrane receptor protein or a portion thereof, such as an extracellular domain or a transmembrane and intracellular domain; a ligand or a portion thereof which binds to a transmembrane receptor protein; an enzyme or portion thereof which is catalytically active; a polypeptide or peptide which promotes oligomerization, such as a leucine zipper domain; a polypeptide or peptide which increases stability, such as an immunoglobulin constant region; and a polypeptide which has a therapeutic activity different from the polypeptide or variant thereof.

In certain embodiments, it may be advantageous to combine a nucleic acid sequence encoding an immunogenic target, polypeptide, or derivative thereof with one or more co-stimulatory component(s) such as cell surface proteins, cytokines or chemokines in a composition of the present invention. The co-stimulatory component may be included in the composition as a polypeptide or as a nucleic acid encoding the polypeptide, for example. Suitable co-stimulatory molecules include, for instance, polypeptides that bind members of the CD28 family (i.e., CD28, ICOS; Hutloff, et al. *Nature* 1999, 397: 263–265; Peach, et al. *J Exp Med* 1994; 180: 2049–2058) such as the CD28 binding polypeptides B7.1 (CD80; Schwartz, 1992; Chen et al, 1992; Ellis, et al. *J. Immunol.*, 156(8): 2700-9) and B7.2 (CD86; Ellis, et al. *J. Immunol.*, 156(8): 2700-9); polypeptides which bind members of the integrin family (i.e., LFA-1 (CD11a / CD18); Sedwick, et al. *J Immunol* 1999, 162: 1367–1375; Wülfing, et al. *Science* 1998, 282: 2266–2269; Lub, et al. *Immunol Today* 1995, 16: 479–483) including members of the ICAM family (i.e., ICAM-1, -2 or -3); polypeptides which bind CD2 family members (i.e., CD2, signalling lymphocyte activation molecule (CDw150 or "SLAM"; Aversa, et al. *J Immunol* 1997, 158: 4036–4044) such as CD58 (LFA-3; CD2 ligand; Davis, et al. *Immunol Today* 1996, 17: 177–187) or SLAM ligands (Sayos, et al. *Nature* 1998, 395: 462–469); polypeptides which bind heat stable antigen (HSA or CD24; Zhou, et al. *Eur J Immunol* 1997, 27: 2524–2528); polypeptides which bind to members of the TNF receptor (TNFR) family (i.e., 4-1BB (CD137; Vinay, et al. *Semin Immunol* 1998, 10: 481–489)), OX40 (CD134; Weinberg, et

al. *Semin Immunol* 1998, 10: 471-480; Higgins, et al. *J Immunol* 1999, 162: 486-493), and CD27 (Lens, et al. *Semin Immunol* 1998, 10: 491-499)) such as 4-1BBL (4-1BB ligand; Vinay, et al. *Semin Immunol* 1998, 10: 481-48; DeBenedette, et al. *J Immunol* 1997, 158: 551-559), TNFR associated factor-1 (TRAF-1; 4-1BB ligand; Saoulli, et al. *J Exp Med* 1998, 187: 1849-1862, Arch, et al. *Mol Cell Biol* 1998, 18: 558-565), TRAF-2 (4-1BB and OX40 ligand; Saoulli, et al. *J Exp Med* 1998, 187: 1849-1862; Oshima, et al. *Int Immunol* 1998, 10: 517-526, Kawamata, et al. *J Biol Chem* 1998, 273: 5808-5814), TRAF-3 (4-1BB and OX40 ligand; Arch, et al. *Mol Cell Biol* 1998, 18: 558-565; Jang, et al. *Biochem Biophys Res Commun* 1998, 242: 613-620; Kawamata S, et al. *J Biol Chem* 1998, 273: 5808-5814), OX40L (OX40 ligand; Gramaglia, et al. *J Immunol* 1998, 161: 6510-6517), TRAF-5 (OX40 ligand; Arch, et al. *Mol Cell Biol* 1998, 18: 558-565; Kawamata, et al. *J Biol Chem* 1998, 273: 5808-5814), and CD70 (CD27 ligand; Couderc, et al. *Cancer Gene Ther.*, 5(3): 163-75). CD154 (CD40 ligand or "CD40L"; Gurunathan, et al. *J. Immunol.*, 1998, 161: 4563-4571; Sine, et al. *Hum. Gene Ther.*, 2001, 12: 1091-1102) may also be suitable.

One or more cytokines may also be suitable co-stimulatory components or "adjuvants", either as polypeptides or being encoded by nucleic acids contained within the compositions of the present invention (Parmiani, et al. Immunol Lett 2000 Sep 15; 74(1): 41-4; Berzofsky, et al. Nature Immunol. 1: 209-219). Suitable cytokines include, for example, interleukin-2 (IL-2) (Rosenberg, et al. *Nature Med.* 4: 321-327 (1998)), IL-4, IL-7, IL-12 (reviewed by Pardoll, 1992; Harries, et al. J. Gene Med. 2000 Jul-Aug;2(4):243-9; Rao, et al. *J. Immunol.* 156: 3357-3365 (1996)), IL-15 (Xin, et al. *Vaccine*, 17:858-866, 1999), IL-16 (Cruikshank, et al. J. Leuk Biol. 67(6): 757-66, 2000), IL-18 (*J. Cancer Res. Clin. Oncol.* 2001. 127(12): 718-726), GM-CSF (CSF (Disis, et al. *Blood*, 88: 202-210 (1996)), tumor necrosis factor-alpha (TNF-α), or interferon-gamma (INF-γ). Other cytokines may also be suitable for practicing the present invention, as is known in the art.

Chemokines may also be utilized. For example, fusion proteins comprising CXCL10 (IP-10) and CCL7 (MCP-3) fused to a tumor self-antigen have been shown to induce anti-tumor immunity (Biragyn, et al. *Nature Biotech.* 1999, 17: 253-258). The chemokines CCL3 (MIP-

1α) and CCL5 (RANTES) (Boyer, et al. *Vaccine*, 1999, 17 (Supp. 2): S53-S64) may also be of use in practicing the present invention. Other suitable chemokines are known in the art.

It is also known in the art that suppressive or negative regulatory immune mechanisms may be blocked, resulting in enhanced immune responses. For instance, treatment with anti-CTLA-4 (Shrikant, et al. *Immunity*, 1996, 14: 145-155; Sutmuller, et al. *J. Exp. Med.*, 2001, 194: 823-832), anti-CD25 (Sutmuller, *supra*), anti-CD4 (Matsui, et al. *J. Immunol.*, 1999, 163: 184-193), the fusion protein IL13Ra2-Fc (Terabe, et al. *Nature Immunol.*, 2000, 1: 515-520), and combinations thereof (i.e., anti-CTLA-4 and anti-CD25, Sutmuller, *supra*) have been shown to upregulate anti-tumor immune responses and would be suitable in practicing the present invention.

Any of these components may be used alone or in combination with other agents. For instance, it has been shown that a combination of CD80, ICAM-1 and LFA-3 ("TRICOM") may potentiate anti-cancer immune responses (Hodge, et al. *Cancer Res.* 59: 5800-5807 (1999). Other effective combinations include, for example, IL-12 + GM-CSF (Ahlers, et al. *J. Immunol.*, 158: 3947-3958 (1997); Iwasaki, et al. *J. Immunol.* 158: 4591-4601 (1997)), IL-12 + GM-CSF + TNF-α (Ahlers, et al. *Int. Immunol.* 13: 897-908 (2001)), CD80 + IL-12 (Fruend, et al. *Int. J. Cancer*, 85: 508-517 (2000); Rao, et al. *supra*), and CD86 + GM-CSF + IL-12 (Iwasaki, supra). One of skill in the art would be aware of additional combinations useful in carrying out the present invention.In addition, the skilled artisan would be aware of additional reagents or methods that may be used to modulate such mechanisms. These reagents and methods, as well as others known by those of skill in the art, may be utilized in practicing the present invention.

Additional strategies for improving the efficiency of nucleic acid-based immunization may also be used including, for example, the use of self-replicating viral replicons (Caley, et al. 1999. *Vaccine*, 17: 3124-2135; Dubensky, et al. 2000. *Mol. Med.* 6: 723-732; Leitner, et al. 2000. *Cancer Res.* 60: 51-55), codon optimization (Liu, et al. 2000. *Mol. Ther.*, 1: 497-500; Dubensky, *supra*; Huang, et al. 2001. *J. Virol.* 75: 4947-4951), *in vivo* electroporation (Widera, et al. 2000. *J. Immunol.* 164: 4635-3640), incorporation of CpG stimulatory motifs (Gurunathan, et al. *Ann. Rev. Immunol.*, 2000, 18: 927-974; Leitner, *supra*), sequences for targeting of the endocytic or ubiquitin-processing pathways (Thomson, et al. 1998. *J. Virol.* 72:

2246-2252; Velders, et al. 2001. *J. Immunol.* 166: 5366-5373), prime-boost regimens (Gurunathan, *supra*; Sullivan, et al. 2000. *Nature*, 408: 605-609; Hanke, et al. 1998. *Vaccine*, 16: 439-445; Amara, et al. 2001. *Science*, 292: 69-74), and the use of mucosal delivery vectors such as *Salmonella* (Darji, et al. 1997. *Cell*, 91: 765-775; Woo, et al. 2001. *Vaccine*, 19: 2945-2954). Other methods are known in the art, some of which are described below.

Chemotherapeutic agents, radiation, anti-angiogenic compounds, or other agents may also be utilized in treating and / or preventing cancer using immunogenic targets (Sebti, et al. Oncogene 2000 Dec 27;19(56):6566-73). For example, in treating metastatic breast cancer, useful chemotherapeutic agents include cyclophosphamide, doxorubicin, paclitaxel, docetaxel, navelbine, capecitabine, and mitomycin C, among others. Combination chemotherapeutic regimens have also proven effective including cyclophosphamide + methotrexate + 5-fluorouracil; cyclophosphamide + doxorubicin + 5-fluorouracil; or, cyclophosphamide + doxorubicin, for example. Other compounds such as prednisone, a taxane, navelbine, mitomycin C, or vinblastine have been utlized for various reasons. A majority of breast cancer patients have estrogen-receptor positive (ER+) tumors and in these patients, endocrine therapy (i.e., tamoxifen) is preferred over chemotherapy. For such patients, tamoxifen or, as a second line therapy, progestins (medroxyprogesterone acetate or megestrol acetate) are preferred. Aromatase inhibitors (i.e., aminoglutethimide and analogs thereof such as letrozole) decrease the availability of estrogen needed to maintain tumor growth and may be used as second or third line endocrine therapy in certain patients.

Other cancers may require different chemotherapeutic regimens. For example, metastatic colorectal cancer is typically treated with Camptosar (irinotecan or CPT-11), 5-fluorouracil or leucovorin, alone or in combination with one another. Proteinase and integrin inhibitors such as as the MMP inhibitors marimastate (British Biotech), COL-3 (Collagenex), Neovastat (Aetema), AG3340 (Agouron), BMS-275291 (Bristol Myers Squibb), CGS 27023A (Novartis) or the integrin inhibitors Vitaxin (Medimmune), or MED1522 (Merck KgaA) may also be suitable for use. As such, immunological targeting of AAs and / or TAs associated with colorectal cancer could be performed in combination with a treatment using those chemotherapeutic agents.

Similarly, chemotherapeutic agents used to treat other types of cancers are well-known in the art and may be combined with the AAs and / or TAs described herein.

Many anti-angiogenic agents are known in the art and would be suitable for co-administration with the AAs and / or TAs of the present invention (see, for example, Timar, et al. 2001. *Pathology Oncol. Res.*, 7(2): 85-94). Such agents include, for example, physiological agents such as growth factors (i.e., ANG-2, NK1,2,4 (HGF), transforming growth factor beta (TGF-β)), cytokines (i.e., interferons such as IFN-α, -β, -γ, platelet factor 4 (PF-4), PR-39), proteases (i.e., cleaved AT-III, collagen XVIII fragment (Endostatin)), HmwKallikrein-d5 plasmin fragment (Angiostatin), prothrombin-F1-2, TSP-1), protease inhibitors (i.e., tissue inhibitor of metalloproteases such as TIMP-1, -2, or –3; maspin; plasminogen activator-inhibitors such as PAI-1; pigment epithelium derived factor (PEDF)), Tumstatin (available through ILEX, Inc.), antibody products (i.e., the collagen-binding antibodies HUIV26, HUI77, XL313; anti-VEGF; anti-integrin (i.e., Vitaxin. (Lxsys))), and glycosidases (i.e., heparinase-I, -III). "Chemical" or modified physiological agents known or believed to have anti-angiogenic potential include, for example, vinblastine, taxol, ketoconazole, thalidomide, dolestatin, combrestatin A, rapamycin (Guba, et al. 2002, *Nature Med.*, 8: 128-135), CEP-7055 (available from Cephalon, Inc.), flavone acetic acid, Bay 12-9566 (Bayer Corp.), AG3340 (Agouron, Inc.), CGS 27023A (Novartis), tetracylcine derivatives (i.e., COL-3 (Collagenix, Inc.)), Neovastat (Aeterna), BMS-275291 (Bristol-Myers Squibb), low dose 5-FU, low dose methotrexate (MTX), irsofladine, radicicol, cyclosporine, captopril, celecoxib, D45152-sulphated polysaccharide, cationic protein (Protamine), cationic peptide-VEGF, Suramin (polysulphonated napthyl urea), compounds that interfere with the function or production of VEGF (i.e., SU5416 or SU6668 (Sugen), PTK787/ZK22584 (Novartis)), Distamycin A, Angiozyme (ribozyme), isoflavinoids, staurosporine derivatives, genistein, EMD121974 (Merck KcgaA), tyrphostins, isoquinolones, retinoic acid, carboxyamidotriazole, TNP-470, octreotide, 2-methoxyestradiol, aminosterols (i.e., squalamine), glutathione analogues (i.e., N-acteyl-L-cysteine), combretastatin A-4 (Oxigene), Eph receptor blocking agents (*Nature*, 414:933-938, 2001), Rh-Angiostatin, Rh-Endostatin, cyclic-RGD peptide, accutin-disintegrin, benzodiazepenes, humanized anti-avb3 Ab, Rh-PAI-2, amiloride, p-amidobenzamidine, anti-uPA ab, anti-uPAR Ab, L-phanylalanine-N-methylamides

(i.e., Batimistat, Marimastat), AG3340, and minocycline. Many other suitable agents are known in the art and would suffice in practicing the present invention.

The present invention may also be utilized in combination with "non-traditional" methods of treating cancer. For example, it has recently been demonstrated that administration of certain anaerobic bacteria may assist in slowing tumor growth. In one study, *Clostridium novyi* was modified to eliminate a toxin gene carried on a phage episome and administered to mice with colorectal tumors (Dang, et al. *P.N.A.S. USA*, 98(26): 15155-15160, 2001). In combination with chemotherapy, the treatment was shown to cause tumor necrosis in the animals. The reagents and methodologies described in this application may be combined with such treatment methodologies.

Nucleic acids encoding immunogenic targets may be administered to patients by any of several available techniques. Various viral vectors that have been successfully utilized for introducing a nucleic acid to a host include retrovirus, adenovirus, adeno-associated virus (AAV), herpes virus, and poxvirus, among others. It is understood in the art that many such viral vectors are available in the art. The vectors of the present invention may be constructed using standard recombinant techniques widely available to one skilled in the art. Such techniques may be found in common molecular biology references such as *Molecular Cloning: A Laboratory Manual* (Sambrook, et al., 1989, Cold Spring Harbor Laboratory Press), *Gene Expression Technology* (Methods in Enzymology, Vol. 185, edited by D. Goeddel, 1991. Academic Press, San Diego, CA), and *PCR Protocols: A Guide to Methods and Applications* (Innis, et al. 1990. Academic Press, San Diego, CA).

Preferred retroviral vectors are derivatives of lentivirus as well as derivatives of murine or avian retroviruses. Examples of suitable retroviral vectors include, for example, Moloney murine leukemia virus (MoMuLV), Harvey murine sarcoma virus (HaMuSV), murine mammary tumor virus (MuMTV), SIV, BIV, HIV and Rous Sarcoma Virus (RSV). A number of retroviral vectors can incorporate multiple exogenous nucleic acid sequences. As recombinant retroviruses are defective, they require assistance in order to produce infectious vector particles. This assistance can be provided by, for example, helper cell lines encoding retrovirus structural genes. Suitable helper cell lines include Ψ2, PA317 and PA12, among others. The vector virions

produced using such cell lines may then be used to infect a tissue cell line, such as NIH 3T3 cells, to produce large quantities of chimeric retroviral virions. Retroviral vectors may be administered by traditional methods (i.e., injection) or by implantation of a "producer cell line" in proximity to the target cell population (Culver, K., *et al.*, 1994, *Hum. Gene Ther.*, 5 (3): 343-79; Culver, K., *et al.*, *Cold Spring Harb. Symp. Quant. Biol.*, 59: 685-90); Oldfield, E., 1993, *Hum. Gene Ther.*, 4 (1): 39-69). The producer cell line is engineered to produce a viral vector and releases viral particles in the vicinity of the target cell. A portion of the released viral particles contact the target cells and infect those cells, thus delivering a nucleic acid of the present invention to the target cell. Following infection of the target cell, expression of the nucleic acid of the vector occurs.

Adenoviral vectors have proven especially useful for gene transfer into eukaryotic cells (Rosenfeld, M., *et al.*, 1991, *Science*, 252 (5004): 431-4; Crystal, R., *et al.*, 1994, *Nat. Genet.*, 8 (1): 42-51), the study eukaryotic gene expression (Levrero, M., *et al.*, 1991, *Gene*, 101 (2): 195-202), vaccine development (Graham, F. and Prevec, L., 1992, *Biotechnology*, 20: 363-90), and in animal models (Stratford-Perricaudet, L., *et al.*, 1992, *Bone Marrow Transplant.*, 9 (Suppl. 1): 151-2 ; Rich, D., *et al.*, 1993, *Hum. Gene Ther.*, 4 (4): 461-76). Experimental routes for administrating recombinant Ad to different tissues *in vivo* have included intratracheal instillation (Rosenfeld, M., *et al.*, 1992, *Cell*, 68 (1): 143-55) injection into muscle (Quantin, B., *et al.*, 1992, *Proc. Natl. Acad. Sci. U.S.A.*, 89 (7): 2581-4), peripheral intravenous injection (Herz, J., and Gerard, R., 1993, *Proc. Natl. Acad. Sci. U.S.A.*, 90 (7): 2812-6) and stereotactic inoculation to brain (Le Gal La Salle, G., *et al.*, 1993, *Science*, 259 (5097): 988-90), among others.

Adeno-associated virus (AAV) demonstrates high-level infectivity, broad host range and specificity in integrating into the host cell genome (Hermonat, P., et al., 1984, *Proc. Natl. Acad. Sci. U.S.A.*, 81 (20): 6466-70). And Herpes Simplex Virus type-1 (HSV-1) is yet another attractive vector system, especially for use in the nervous system because of its neurotropic property (Geller, A., *et al.*, 1991, *Trends Neurosci.*, 14 (10): 428-32; Glorioso, *et al.*, 1995, *Mol. Biotechnol.*, 4 (1): 87-99; Glorioso, *et al.*, 1995, *Annu. Rev. Microbiol.*, 49: 675-710).

Alphavirus may also be used to express the immunogenic target in a host. Suitable members of the Alphavirus genus include, among others, Sindbis virus, Semliki Forest virus

(SFV), the Ross River virus and Venezuelan, Western and Eastern equine encephalitis viruses, among others. Expression systems utilizing alphavirus vectors are described in, for example, U.S. Pat. Nos. 5,091,309; 5,217,879; 5,739,026; 5,766,602; 5,843,723; 6,015,694; 6,156,558; 6,190,666; 6,242,259; and, 6,329,201; WO 92/10578; Xiong et al., Science, Vol 243, 1989, 1188-1191; Liliestrom, et al. Bio/Technology, 9: 1356-1361, 1991. Thus, the use of alphavirus as an expression system is well known by those of skill in the art.

Poxvirus is another useful expression vector (Smith, et al. 1983, *Gene*, 25 (1): 21-8; Moss, et al, 1992, *Biotechnology*, 20: 345-62; Moss, et al, 1992, *Curr. Top. Microbiol. Immunol.*, 158: 25-38; Moss, et al. 1991. *Science*, 252: 1662-1667). The most often utilized poxviral vectors include vaccinia and derivatives therefrom such as NYVAC, and members of the avipox genera such as fowlpox, canarypox, ALVAC, and ALVAC(2), among others.

NYVAC (vP866) was derived from the Copenhagen vaccine strain of vaccinia virus by deleting six nonessential regions of the genome encoding known or potential virulence factors (see, for example, U.S. Pat. Nos. 5,364,773 and 5,494,807). The deletion loci were also engineered as recipient loci for the insertion of foreign genes. The deleted regions are: thymidine kinase gene (TK; J2R); hemorrhagic region (u; B13R+B14R); A type inclusion body region (ATI; A26L); hemagglutinin gene (HA; A56R); host range gene region (C7L-K1L); and, large subunit, ribonucleotide reductase (I4L). NYVAC is a genetically engineered vaccinia virus strain that was generated by the specific deletion of eighteen open reading frames encoding gene products associated with virulence and host range. NYVAC has been show to be useful for expressing TAs (see, for example, U.S. Pat. No. 6,265,189). NYVAC (vP866), vP994, vCP205, vCP1433, placZH6H4Lreverse, pMPC6H6K3E3 and pC3H6FHVB were also deposited with the ATCC under the terms of the Budapest Treaty, accession numbers VR-2559, VR-2558, VR-2557, VR-2556, ATCC-97913, ATCC-97912, and ATCC-97914, respectively.

ALVAC-based recombinant viruses (i.e., ALVAC-1 and ALVAC-2) are also suitable for use in practicing the present invention (see, for example, U.S. Pat. No. 5,756,103). ALVAC(2) is identical to ALVAC(1) except that ALVAC(2) genome comprises the vaccinia E3L and K3L genes under the control of vaccinia promoters (U.S. Pat. No. 6,130,066; Beattie et al., 1995a, 1995b, 1991; Chang et al., 1992; Davies et al., 1993). Both ALVAC(1) and ALVAC(2) have

been demonstrated to be useful in expressing foreign DNA sequences, such as TAs (Tartaglia et al., 1993 a,b; U.S. Pat. No. 5,833,975). ALVAC was deposited under the terms of the Budapest Treaty with the American Type Culture Collection (ATCC), 10801 University Boulevard, Manassas, Va. 20110-2209, USA, ATCC accession number VR-2547.

Another useful poxvirus vector is TROVAC. TROVAC refers to an attenuated fowlpox that was a plaque-cloned isolate derived from the FP-1 vaccine strain of fowlpoxvirus which is licensed for vaccination of 1 day old chicks. TROVAC was likewise deposited under the terms of the Budapest Treaty with the ATCC, accession number 2553.

"Non-viral" plasmid vectors may also be suitable in practicing the present invention. Plasmid DNA molecules comprising expression cassettes for expressing an immunogenic target may be used for "naked DNA" immunization. Preferred plasmid vectors are compatible with bacterial, insect, and / or mammalian host cells. Such vectors include, for example, PCR-II, pCR3, and pcDNA3.1 (Invitrogen, San Diego, CA), pBSII (Stratagene, La Jolla, CA), pET15 (Novagen, Madison, WI), pGEX (Pharmacia Biotech, Piscataway, NJ), pEGFP-N2 (Clontech, Palo Alto, CA), pETL (BlueBacII, Invitrogen), pDSR-alpha (PCT pub. No. WO 90/14363) and pFastBacDual (Gibco-BRL, Grand Island, NY) as well as Bluescript® plasmid derivatives (a high copy number COLE1-based phagemid, Stratagene Cloning Systems, La Jolla, CA), PCR cloning plasmids designed for cloning Taq-amplified PCR products (*e.g.*, TOPO™ TA cloning® kit, PCR2.1® plasmid derivatives, Invitrogen, Carlsbad, CA).

Bacterial vectors may also be used with the current invention. These vectors include, for example, *Shigella, Salmonella, Vibrio cholerae, Lactobacillus, Bacille calmette guérin (BCG), and Streptococcus* (see for example, WO 88/6626; WO 90/0594; WO 91/13157; WO 92/1796; and WO 92/21376). Many other non-viral plasmid expression vectors and systems are known in the art and could be used with the current invention.

Suitable nucleic acid delivery techniques include DNA-ligand complexes, adenovirus-ligand-DNA complexes, direct injection of DNA, $CaPO_4$ precipitation, gene gun techniques, electroporation, and colloidal dispersion systems, among others. Colloidal dispersion systems include macromolecule complexes, nanocapsules, microspheres, beads, and lipid-based systems including oil-in-water emulsions, micelles, mixed micelles, and liposomes. The preferred

colloidal system of this invention is a liposome, which are artificial membrane vesicles useful as delivery vehicles *in vitro* and *in vivo*. RNA, DNA and intact virions can be encapsulated within the aqueous interior and be delivered to cells in a biologically active form (Fraley, R., *et al.*, 1981, *Trends Biochem. Sci.*, 6: 77). The composition of the liposome is usually a combination of phospholipids, particularly high-phase-transition-temperature phospholipids, usually in combination with steroids, especially cholesterol. Other phospholipids or other lipids may also be used. The physical characteristics of liposomes depend on pH, ionic strength, and the presence of divalent cations. Examples of lipids useful in liposome production include phosphatidyl compounds, such as phosphatidylglycerol, phosphatidylcholine, phosphatidylserine, phosphatidylethanolamine, sphingolipids, cerebrosides, and gangliosides. Particularly useful are diacylphosphatidylglycerols, where the lipid moiety contains from 14-18 carbon atoms, particularly from 16-18 carbon atoms, and is saturated. Illustrative phospholipids include egg phosphatidylcholine, dipalmitoylphosphatidylcholine and distearoylphosphatidylcholine.

An immunogenic target may also be administered in combination with one or more adjuvants to boost the immune response. Exemplary adjuvants are shown in Table I below:

Table I

Types of Immunologic Adjuvants

Type of Adjuvant	General Examples	Specific Examples/References
1 Gel-type	Aluminum hydroxide/phosphate ("alum adjuvants")	(Aggerbeck and Heron, 1995)
	Calcium phosphate	(Relyveld, 1986)
2 Microbial	Muramyl dipeptide (MDP)	(Chedid et al., 1986)
	Bacterial exotoxins	Cholera toxin (CT), *E.coli* labile toxin (LT)(Freytag and Clements, 1999)
	Endotoxin-based adjuvants	Monophosphoryl lipid A (MPL) (Ulrich and Myers, 1995)
	Other bacterial	CpG oligonucleotides (Cerral and Petray, 2000), BCG sequences (Krieg, et al. *Nature*, 374:576), tetanus toxoid (Rice, et al. *J. Immunol.*, 2001, 167: 1558-1565)
3 Particulate	Biodegradable polymer microspheres	(Gupta et al., 1998)
	Immunostimulatory complexes (ISCOMs)	(Morein and Bengtsson, 1999)
	Liposomes	(Wassef et al., 1994)

4 Oil-emulsion and surfactant-based adjuvants	Freund's incomplete adjuvant	(Jensen et al., 1998)
	Microfluidized emulsions	MF59 (Ott et al., 1995)
		SAF (Allison and Byars, 1992) (Allison, 1999)
	Saponins	QS-21 (Kensil, 1996)
5 Synthetic	Muramyl peptide derivatives	Murabutide (Lederer, 1986) Threony-MDP (Allison, 1997)
	Nonionic block copolymers	L121 (Allison, 1999)
	Polyphosphazene (PCPP)	(Payne et al., 1995)
	Synthetic polynucleotides	Poly A:U, Poly I:C (Johnson, 1994)

The immunogenic targets of the present invention may also be used to generate antibodies for use in screening assays or for immunotherapy. Other uses would be apparent to one of skill in the art. The term "antibody" includes antibody fragments, as are known in the art, including Fab, Fab_2, single chain antibodies (Fv for example), humanized antibodies, chimeric antibodies, human antibodies, produced by several methods as are known in the art. Methods of preparing and utilizing various types of antibodies are well-known to those of skill in the art and would be suitable in practicing the present invention (see, for example, Harlow, et al. *Antibodies: A Laboratory Manual*, Cold Spring Harbor Laboratory, 1988; Harlow, et al. *Using Antibodies: A Laboratory Manual, Portable Protocol No. 1*, 1998; Kohler and Milstein, Nature, 256:495 (1975)); Jones et al. Nature, 321:522-525 (1986); Riechmann et al. Nature, 332:323-329 (1988); Presta (Curr. Op. Struct. Biol., 2:593-596 (1992); Verhoeyen et al. (Science, 239:1534-1536 (1988); Hoogenboom et al., J. Mol. Biol., 227:381 (1991); Marks et al., J. Mol. Biol., 222:581 (1991); Cole et al., Monoclonal Antibodies and Cancer Therapy, Alan R. Liss, p. 77 (1985); Boerner et al., J. Immunol., 147(1):86-95 (1991); Marks et al., Bio/Technology 10, 779-783 (1992); Lonberg et al., Nature 368 856-859 (1994); Morrison, Nature 368 812-13 (1994); Fishwild et al., Nature Biotechnology 14, 845-51 (1996); Neuberger, Nature Biotechnology 14, 826 (1996); Lonberg and Huszar, Intern. Rev. Immunol. 13 65-93 (1995); as well as U.S. Pat. Nos. 4,816,567; 5,545,807; 5,545,806; 5,569,825; 5,625,126; 5,633,425; and, 5,661,016). The antibodies or derivatives therefrom may also be conjugated to therapeutic moieties such as cytotoxic drugs or toxins, or active fragments thereof such as diptheria A chain, exotoxin A chain, ricin A chain, abrin A chain, curcin, crotin, phenomycin, enomycin, among others. Cytotoxic agents may also include radiochemicals. Antibodies and their derivatives may be incorporated into compositions of the invention for use *in vitro* or *in vivo*.

Nucleic acids, proteins, or derivatives thereof representing an immunogenic target may be used in assays to determine the presence of a disease state in a patient, to predict prognosis, or to determine the effectiveness of a chemotherapeutic or other treatment regimen. Expression profiles, performed as is known in the art, may be used to determine the relative level of expression of the immunogenic target. The level of expression may then be correlated with base levels to determine whether a particular disease is present within the patient, the patient's prognosis, or whether a particular treatment regimen is effective. For example, if the patient is being treated with a particular chemotherapeutic regimen, an decreased level of expression of an immunogenic target in the patient's tissues (i.e., in peripheral blood) may indicate the regimen is decreasing the cancer load in that host. Similarly, if the level of expresssion is increasing, another therapeutic modality may need to be utilized. In one embodiment, nucleic acid probes corresponding to a nucleic acid encoding an immunogenic target may be attached to a biochip, as is known in the art, for the detection and quantification of expression in the host.

It is also possible to use nucleic acids, proteins, derivatives therefrom, or antibodies thereto as reagents in drug screening assays. The reagents may be used to ascertain the effect of a drug candidate on the expression of the immunogenic target in a cell line, or a cell or tissue of a patient. The expression profiling technique may be combined with high throughput screening techniques to allow rapid identification of useful compounds and monitor the effectiveness of treatment with a drug candidate (see, for example, Zlokarnik, et al., Science 279, 84-8 (1998)). Drug candidates may be chemical compounds, nucleic acids, proteins, antibodies, or derivatives therefrom, whether naturally occurring or synthetically derived. Drug candidates thus identified may be utilized, among other uses, as pharmaceutical compositions for administration to patients or for use in further screening assays.

Administration of a composition of the present invention to a host may be accomplished using any of a variety of techniques known to those of skill in the art. The composition(s) may be processed in accordance with conventional methods of pharmacy to produce medicinal agents for administration to patients, including humans and other mammals (i.e., a "pharmaceutical composition"). The pharmaceutical composition is preferably made in the form of a dosage unit containing a given amount of DNA, viral vector particles, polypeptide, peptide, or other drug

candidate, for example. A suitable daily dose for a human or other mammal may vary widely depending on the condition of the patient and other factors, but, once again, can be determined using routine methods.

The pharmaceutical composition may be administered orally, parentally, by inhalation spray, rectally, intranodally, or topically in dosage unit formulations containing conventional pharmaceutically acceptable carriers, adjuvants, and vehicles. The term "pharmaceutically acceptable carrier" or "physiologically acceptable carrier" as used herein refers to one or more formulation materials suitable for accomplishing or enhancing the delivery of a nucleic acid, polypeptide, or peptide as a pharmaceutical composition. A "pharmaceutical composition" is a composition comprising a therapeutically effective amount of a nucleic acid or polypeptide. The terms "effective amount" and "therapeutically effective amount" each refer to the amount of a nucleic acid or polypeptide used to induce or enhance an effective immune response. It is preferred that compositions of the present invention provide for the induction or enhancement of an anti-tumor immune response in a host which protects the host from the development of a tumor and / or allows the host to eliminate an existing tumor from the body.

For oral administration, the pharmaceutical composition may be of any of several forms including, for example, a capsule, a tablet, a suspension, or liquid, among others. Liquids may be administered by injection as a composition with suitable carriers including saline, dextrose, or water. The term parenteral as used herein includes subcutaneous, intravenous, intramuscular, intrasternal, infusion, or intraperitoneal administration. Suppositories for rectal administration of the drug can be prepared by mixing the drug with a suitable non-irritating excipient such as cocoa butter and polyethylene glycols that are solid at ordinary temperatures but liquid at the rectal temperature.

The dosage regimen for immunizing a host or otherwise treating a disorder or a disease with a composition of this invention is based on a variety of factors, including the type of disease, the age, weight, sex, medical condition of the patient, the severity of the condition, the route of administration, and the particular compound employed. For example, a poxviral vector may be administered as a composition comprising 1 x 10^6 infectious particles per dose. Thus, the dosage regimen may vary widely, but can be determined routinely using standard methods.

Injectable preparations, such as sterile injectable aqueous or oleaginous suspensions, may be formulated according to known methods using suitable dispersing or wetting agents and suspending agents. The injectable preparation may also be a sterile injectable solution or suspension in a non-toxic parenterally acceptable diluent or solvent. Suitable vehicles and solvents that may be employed are water, Ringer's solution, and isotonic sodium chloride solution, among others. For instance, a viral vector such as a poxvirus may be prepared in 0.4% NaCl. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose, any bland fixed oil may be employed, including synthetic mono- or diglycerides. In addition, fatty acids such as oleic acid find use in the preparation of injectables.

For topical administration, a suitable topical dose of a composition may be administered one to four, and preferably two or three times daily. The dose may also be administered with intervening days during which no does is applied. Suitable compositions may comprise from 0.001% to 10% w/w, for example, from 1% to 2% by weight of the formulation, although it may comprise as much as 10% w/w, but preferably not more than 5% w/w, and more preferably from 0.1% to 1% of the formulation. Formulations suitable for topical administration include liquid or semi-liquid preparations suitable for penetration through the skin (*e.g.*, liniments, lotions, ointments, creams, or pastes) and drops suitable for administration to the eye, ear, or nose.

The pharmaceutical compositions may also be prepared in a solid form (including granules, powders or suppositories). The pharmaceutical compositions may be subjected to conventional pharmaceutical operations such as sterilization and/or may contain conventional adjuvants, such as preservatives, stabilizers, wetting agents, emulsifiers, buffers etc. Solid dosage forms for oral administration may include capsules, tablets, pills, powders, and granules. In such solid dosage forms, the active compound may be admixed with at least one inert diluent such as sucrose, lactose, or starch. Such dosage forms may also comprise, as in normal practice, additional substances other than inert diluents, *e.g.*, lubricating agents such as magnesium stearate. In the case of capsules, tablets, and pills, the dosage forms may also comprise buffering agents. Tablets and pills can additionally be prepared with enteric coatings. Liquid dosage forms for oral administration may include pharmaceutically acceptable emulsions, solutions, suspensions, syrups, and elixirs containing inert diluents commonly used in the art, such as

water. Such compositions may also comprise adjuvants, such as wetting sweetening, flavoring, and perfuming agents.

Pharmaceutical compositions comprising a nucleic acid, polypeptide, or other compound of the present invention may take any of several forms and may be administered by any of several routes. In preferred embodiments, the compositions are administered via a parenteral route (intradermal, intramuscular or subcutaneous) to induce an immune response in the host. Alternatively, the composition may be administered directly into a lymph node (intranodal) or tumor mass (i.e., intratumoral administration). For example, the dose could be administered subcutaneously at days 0, 7, and 14. Suitable methods for immunization using compositions comprising TAs are known in the art, as shown for p53 (Hollstein et al., 1991), p21-ras (Almoguera et al., 1988), HER-2 (Fendly et al., 1990), the melanoma-associated antigens (MAGE-1; MAGE-2) (van der Bruggen et al., 1991), p97 (Hu et al., 1988), and carcinoembryonic antigen (CEA) (Kantor et al., 1993; Fishbein et al., 1992; Kaufman et al., 1991), among others.

Preferred embodiments of administratable compositions include, for example, nucleic acids or polypeptides in liquid preparations such as suspensions, syrups, or elixirs. Preferred injectable preparations include, for example, nucleic acids or polypeptides suitable for parental, subcutaneous, intradermal, intramuscular or intravenous administration such as sterile suspensions or emulsions. For example, a recombinant poxvirus may be in admixture with a suitable carrier, diluent, or excipient such as sterile water, physiological saline, glucose or the like. The composition may also be provided in lyophilized form for reconstituting, for instance, in isotonic aqueous, saline buffer. In addition, the compositions can be co-administered or sequentially administered with other antineoplastic, anti-tumor or anti-cancer agents and/or with agents which reduce or alleviate ill effects of antineoplastic, anti-tumor or anti-cancer agents.

While the compositions of the invention can be administered as the sole active pharmaceutical agent, they can also be used in combination with one or more other compositions or agents (i.e., other immunogenic targets, co-stimulatory molecules, adjuvants). When administered as a combination, the individual components can be formulated as separate

compositions administered at the same time or different times, or the components can be combined as a single composition.

Compositions for vaccination may also be used in a "prime-boost" regimen (WO 01/30382 A1) in which the targeted immunogen is initially administered in a priming step in one form (i.e., a nucleic acid or peptide) followed by a boosting step in which the targeted immunogen is administered in another form. The form of the targeted immunogen in the priming and boosting steps are different. For instance, if the priming step utilized a nucleic acid, the boost would be administered as a peptide. This method of administration has been shown to induce strong immunological responses.

A kit comprising a composition of the present invention is also provided. The kit can include a separate container containing a suitable carrier, diluent or excipient. The kit can also include an additional anti-cancer, anti-tumor or antineoplastic agent and/or an agent that reduces or alleviates ill effects of antineoplastic, anti-tumor or anti-cancer agents for co- or sequential-administration. Additionally, the kit can include instructions for mixing or combining ingredients and/or administration. A kit may provide reagents for performing screening assays, such as one or more PCR primers, hybridization probes, and / or biochips, for example.

A better understanding of the present invention and of its many advantages will be had from the following examples, given by way of illustration.

EXAMPLES

Example 1

AAC2 Tumor Associated Antigen

A version of the AAC2 coding sequence (AAC2-1) was provided by a collaborator and found to have high sequence similarity to a murine bcl-6-associated zinc finger protein ("BAZF"). Based on this sequence information, PCR primers were designed as shown below:

CACCATGGGT TCCCCCGCCG CCCCGGA (forward primer; **SEQ ID NO.: 6**)

CTAGGGCCCC CCGAGAATGT GGTAGTGCAC TTT (reverse primer; **SEQ ID NO.: 7**)

RNA was isolated from confluent HUVEC (BioWhittacker; Cat. No. CC2517, Lot No. 1F0141) cultures using Trizol™ as indicated by the manufacturer (Life Technologies, Inc., Cat. No. 15596). High fidelity RT-PCR was then performed using the forward and reverse primers (24 cycles at 94 degrees, 2 min.; 94 degrees, 30 sec; 56.8 degrees, 30 sec; 68 degrees, 1 min 40 sec; cycle 25 is 68 degrees, 7 min) resulting in the isolation of a 1,447 base pair cDNA. The cDNA was cloned into the pEF6-TOPO eukaryotic expression plasmid and termed "pEF6-hAAC2-2". The cDNA pEF6-hAAC2-2 was sequenced using four primers and aligned to the sequence of AAC2-1 and murine BAZF (**Fig. 1**). As shown therein, AAC2-2 is missing the serine residue (S) found at position 245 in AAC2-1. Secondly, a stretch of 17 amino acids at positions 298 to 316 (SEFFSCQNCEAVAGCSS) of AAC2-2 showed only 11.8% sequence identity with amino acids 298-316 of AAC2-1 (**Fig. 1**). Interestingly, the stretch of 17 amino acids between positions 298 and 316 is 100% identical with murine BAZF suggesting that this may be critical for transcription factor function along with the long stretch of serines (zinc finger). AAC2-2 was then cloned into the pcDNA3.1-zeo eukaryotic expression plasmid ("pcDNA3.1-hAAC2-2").

Example 2

Human T-cell Reactivity Against AAC-2 Peptides

Using the AAC2-2 amino acid sequence, a library of 9-mer peptides predicted to bind to HLA-A-0201 was constructed (**Table II**; in Table II, "N" indicates the sequence is not found within the mouse homolog, while "Y" indicates the sequence is found within the mouse homolog). Twenty-three of the peptides were dissolved in DMSO at 10 mg/ml (**Table III**) and used in human PBMC cultures to test for their ability to elicit CD8 and CD4 αβ T-cell responses *in vitro*.

Table II: *Predicted HLA-A-0201-binding nonamer peptides of human AAC2-2*

Designation	Sequence	Position in Protein	SEQ ID NO.
CLP-2954	RLSPTAATV	AAC2(258-264)	8
CLP-2955	SIFRGRAGV	AAC2(65-73)	9
CLP-2956	DVLGNLNEL	AAC2(23-31)	10
CLP-2957	GVGVDVLSL	AAC2(72-80)	11
CLP-2958	LLTSQAQDT	AAC2(277-285)	12
CLP-2959	VLNSQASQA	AAC2(201-209)	13
CLP-2960	VQFKCGAPA	AAC2(264-272)	14
CLP-2961	GQPCPQARL	AAC2(219-227)	15
CLP-2962	GAHRGLDSL	AAC2(312-320)	16
CLP-2963	GAPASTPYL	AAC2(269-277)	17
CLP-2964	VVQACHRFI	AAC2(123-131)	18
CLP-2965	PLGISLRPL	AAC2(137-145)	19
CLP-2966	PLRAHKAVL	AAC2(48-56)	20
CLP-2967	FVQVAHLRA	AAC2(394-402)	21
CLP-2968	APLLDFMYT	AAC2(90-98)	22
CLP-2969	RAGVGVDVL	AAC2(70-78)	23
CLP-2970	CETCGSRFV	AAC2(387-395)	24
CLP-2971	ATAPAVLAA	AAC2(106-114)	25
CLP-2972	SRFVQVAHL	AAC2(392-400)	26
CLP-2973	CNWKKYKYI	AAC2(192-200)	27
CLP-2974	SPAAPEGAL	AAC2(3-11)	28
EC-1	ALGYVREFT	AAC2(10-18)	29
EC-3	RLRGILTDV	AAC2(32-40)	30
EC-4	GILTDVTLL	AAC2(35-43)	31
EC-5	ILTDVTLLV	AAC2(36-44)	32
EC-6	TLLVGGQPL	AAC2(41-49)	33
EC-9	FMYTSRLRL	AAC2(95-103)	34
EC-10	RLSPATAPA	AAC2(102-110)	35
EC-11	AVLAAATYL	AAC2(110-118)	36
EC-12	ATYLQMEHV	AAC2(115-123)	37
EC-13	LQMEHVVQA	AAC2(118-126)	38
EC-21	QVAHLRAHV	AAC2(390-398)	39
EC-22	HLQTLKSHV	AAC2(418-426)	40
EC-24	VVQACHRFI	AAC2(123-131)	41

Using GM-CSF and IL-4, dendritic cells (DC) were generated from peripheral blood monocytes of blood donors expressing HLA-A-0201. DC were pulsed with the different pools of 9-mer AAC2-2 peptides shown in **Table III**.

Table III: *AAC2-2 Peptide Groups*

Group #	Peptide No.	Sequences	Positions in Protein
1	CLP 2954	RLSPTAATV	AAC2(256-264)
	CLP 2956	DVLGNLNEL	AAC2(23-31)
	CLP 2957	GVGVDVLSL	AAC2(72-80)
2	CLP 2959	VLNSQASQA	AAC2(201-209)
	CLP 2960	VQFKCGAPA	AAC2(264-272)
	CLP 2963	GAPASTPYL	AAC2(269-277)
3	CLP 2964	VVQACHRFI	AAC2(123-131)
	CLP 2968	APLLDFMYT	AAC2(90-98)
4	CLP 2971	ATAPAVLAA	AAC2(106-114)
	CLP 2973	CNWKKYKYI	AAC2(192-200)
5	EC 1	ALGYVREFT	AAC2(10-18)
	EC 3	RLRGILTDV	AAC2(32-40)
	EC 3	GILTDVTLL	AAC2(35-43)
6	EC 5	ILTDVTLLV	AAC2(36-44)
	EC 6	TLLVGGQPL	AAC2(41-49)
	EC 9	FMYTSRLRL	AAC2(95-103)
7	EC 10	RLSPATAPA	AAC2(102-110)
	EC 11	AVLAAATYL	AAC2(110-118)
	EC 12	ATYLQMEHV	AAC2(115-123)
8	EC 13	LQMEHVVQA	AAC2(118-126)
	EC 21	QVAHLRAHV	AAC2(390-398)
9	EC 22	HLQTLKSHV	AAC2(418-426)
	EC 24	VVQACHRFI	AAC2(123-131)

These DC were used to stimulate autologous T-cell-enriched PBMC preparations. The T cells were re-stimulated with autologous PBMC and then re-stimulated with CD40-ligand-activated autologous B cells. After the third and fourth round of stimulation with each peptide pool, ELISPOT analysis for IFN-γ production indicated that the T cells responded most strongly to one of the pools of AAC2-2 peptides (peptide group 6; **Fig. 2A**). Peptide group 6 includes the following peptides: ILTDVTLLV (aa 36-44), TLLVGGQPL (aa 41-49), and FMYTSRLRL (aa 95-103). Flow cytometric analysis (FACS) showed that the lymphocytes from this peptide-specific line consisted of >50% CD8 T cells with a memory ($CD45RO^+$) phenotype. Very few cells (<2%) were stained with anti-CD56 antibodies, indicating that the observed IFN-γ production was not due to NK cell activity.

Analysis of CTL activity from this peptide pool-specific T-cell line also demonstrated that the activated T cells were capable of killing peptide-loaded TAP-deficient T2 cells in an HLA-A-0201-restricted fashion (**Fig. 2B**). This analysis also revealed that ILTDVTLLV was a dominant peptide that stimulated the majority of the peptide-specific CTL activity. Thus, it was determined that AAC2-2 peptides are immunogenic in the human immune system.

EXAMPLE 3

Immunogenicity of AAC2-2 in vivo

Using DNA immunization into HLA-A2-Kb transgenic mice, it was found that the AAC2-2 protein is processed into immunogenic peptides and can elicit an HLA-A-0201-restricted T-cell response *in vivo*. Mice were immunized on day 1 by injection with pEF6-hAAC2-2 and boosted with the same plasmid at day 21. Lymphocytes were harvested from immunized mice 21 days after boosting and re-stimulated *in vitro* with the different groups of AAC2-2 peptides shown in **Table III**. Peptide-specific effector T-cell function towards these peptides was found using IFN-γ ELISPOT analysis (**Fig. 3**). It was found that the same pool of peptides (group 6) previously shown to be strongly immunogenic in human PBMC cultures also elicited significant reactivity by T cells after DNA vaccination (**Fig. 3**). Thus, the AAC2 gene product administered as a DNA-based vaccine is immunogenic *in vivo* and elicits a strong cell-mediated immune response characterized by the activation of CTL activity.

EXAMPLE 4

Therapeutic AAC2-2 Vaccine

Therapeutic vaccination against the AAC2-2 gene product using the pEF6-hAAC2-2 DNA vaccine was found to completely block the growth of a solid tumor. Groups of eight C57BL/6 mice were subcutaneously challenged with 10^6 B16F10 melanoma cells, a vigorous and relatively non-immunogenic tumor cell line. The mice were then immunized at weekly intervals starting at 6 days after tumor challenge. Control mice (eight per group) treated either with a plasmid encoding the flu-NP protein or saline alone all developed large tumors. In contrast, all the mice (8/8) immunized with pEF6-hAAC2-2 had no detectable tumor over a 50-day period (**Fig. 4**). All mice remained tumor-free through 80 days (data not shown). **Fig. 5** plots the survival of mice treated with the different DNA vectors shown after melanoma implantation showing again the complete effectiveness of AAC2-2 vaccination in protecting mice against melanoma growth. No adverse health effects have been observed as a result of immunization with the human AAC2-2 gene-encoding vector (immunized mice were as active as control mice and showed no weight loss).

As shown in **Figs. 4** and **5**, vaccination with a plasmid encoding the human VEGFR-2 (pBLAST-hflk1) did not protect tumor-challenged mice. In fact, the tumors grew even more rapidly in these mice. Analysis of sera from mice vaccinated with the pBLAST-hflk1 plasmid by ELISA found that IgG against the VEGFR-2 protein is induced in significant titres (data not shown). These results suggest that an antibody-based immune response directed against VEGFR-2 may not be not effective in preventing angiogenesis and solid tumor growth.

Inhibition of melanoma solid tumor growth in C57BL/6 mice immunized with pEF6-hAAC2-2 correlates with an immune response against the protein (**Fig. 6**). Immunization of C57BL/6 mice was performed as described above. Spleen cells from immunized mice were re-stimulated with the same peptide pools used in experiments with HLA-A2-Kb transgenic mice (**Table III**). A significant number of peptides cross-react on C57BL/6 class I MHC (Kb and Db molecules). Two pools of peptides in particular (group 1 and group 5) were found to elicit strong effector cell activity in the IFN-γ ELISPOT assays (**Fig. 6**). All of the peptides in these groups are also identical to the corresponding sequence in the murine BAZF protein. These results

strongly suggest that immunization with the human AAC2-2 activates an immune response against its murine orthologue BAZF in mice and can inhibit tumor angiogenesis as a result. Similar results were not seen in all experiments.

While the present invention has been described in terms of the preferred embodiments, it is understood that variations and modifications will occur to those skilled in the art. Therefore, it is intended that the appended claims cover all such equivalent variations that come within the scope of the invention as claimed.

CLAIMS

What is claimed is:

1. An expression vector for inducing an anti-tumor immune response in a patient, said vector comprising a nucleic acid sequence encoding the angiogenesis-associated antigen AAC2-1 or AAC2-2.
2. An expression vector for inducing an anti-tumor immune response in a patient, the vector comprising a nucleic acid sequence encoding at least one amino acid sequence selected from the group consisting of ILTDVTLLV, RLRGILTDV, and GILTDVTLL.
3. The expression vector of claim 1 or 2 wherein the vector is a plasmid or a viral vector.
4. The expression vector of claim 2 wherein the viral vector is selected from the group consisting of poxvirus, adenovirus, retrovirus, herpesvirus, and adeno-associated virus.
5. The expression vector of claim 3 wherein the viral vector is a poxvirus selected from the group consisting of vaccinia, NYVAC, avipox, canarypox, ALVAC, ALVAC(2), fowlpox, and TROVAC.
6. The expression vector of claim 4 wherein the viral vector is a poxvirus selected from the group consisting of NYVAC, ALVAC, and ALVAC(2).
7. The expression vector of claim 1 or 2 further comprising at least one additional angiogenesis-associated antigen.
8. The expression vector of claim 6 wherein the vector is a plasmid or a viral vector.
9. The expression vector of claim 7 wherein the viral vector is selected from the group consisting of poxvirus, adenovirus, retrovirus, herpesvirus, and adeno-associated virus.
10. The expression vector of claim 8 wherein the viral vector is a poxvirus selected from the group consisting of vaccinia, NYVAC, avipox, canarypox, ALVAC, ALVAC(2), fowlpox, and TROVAC.
11. The expression vector of claim 9 wherein the viral vector is a poxvirus selected from the group consisting of NYVAC, ALVAC, and ALVAC(2).
12. The expression vector of claim 1 or 2 further comprising at least one nucleic sequence encoding a tumor antigen.
13. The expression vector of claim 11 wherein the vector is a plasmid or a viral vector.

14. The expression vector of claim 12 wherein the viral vector is selected from the group consisting of poxvirus, adenovirus, retrovirus, herpesvirus, and adeno-associated virus.
15. The expression vector of claim 13 wherein the viral vector is a poxvirus selected from the group consisting of vaccinia, NYVAC, avipox, canarypox, ALVAC, ALVAC(2), fowlpox, and TROVAC.
16. The expression vector of claim 14 wherein the viral vector is a poxvirus selected from the group consisting of NYVAC, ALVAC, and ALVAC(2).
17. The expression vector of claim 7 further comprising at least one nucleic sequence encoding a tumor antigen.
18. The expression vector of claim 16 wherein the vector is a plasmid or a viral vector.
19. The expression vector of claim 17 wherein the viral vector is selected from the group consisting of poxvirus, adenovirus, retrovirus, herpesvirus, and adeno-associated virus.
20. The expression vector of claim 17 wherein the viral vector is a poxvirus selected from the group consisting of vaccinia, NYVAC, avipox, canarypox, ALVAC, ALVAC(2), fowlpox, and TROVAC.
21. The poxvirus of claim 18 wherein the viral vector is a poxvirus selected from the group consisting of NYVAC, ALVAC, and ALVAC(2).
22. The expression vector of claim 1 or 2 further comprising at least one nucleic acid sequence encoding a co-stimulatory component.
23. The expression vector of claim 22 wherein the vector is a plasmid or a viral vector.
24. The expression vector of claim 23 wherein the viral vector is selected from the group consisting of poxvirus, adenovirus, retrovirus, herpesvirus, and adeno-associated virus.
25. The expression vector of claim 24 wherein the viral vector is a poxvirus selected from the group consisting of vaccinia, NYVAC, avipox, canarypox, ALVAC, ALVAC(2), fowlpox, and TROVAC.
26. The poxvirus of claim 25 wherein the viral vector is a poxvirus selected from the group consisting of NYVAC, ALVAC, and ALVAC(2).
27. The expression vector of claim 22 further comprising at least one nucleic acid sequence encoding an additional angiogenesis-associated antigen.

28. The expression vector of claim 27 wherein the vector is a plasmid or a viral vector.
29. The expression vector of claim 28 wherein the viral vector is selected from the group consisting of poxvirus, adenovirus, retrovirus, herpesvirus, and adeno-associated virus.
30. The expression vector of claim 29 wherein the viral vector is a poxvirus selected from the group consisting of vaccinia, NYVAC, avipox, canarypox, ALVAC, ALVAC(2), fowlpox, and TROVAC.
31. The poxvirus of claim 30 wherein the viral vector is a poxvirus selected from the group consisting of NYVAC, ALVAC, and ALVAC(2).
32. The expression vector of claim 22 further comprising at least one nucleic acid encoding a tumor antigen.
33. The expression vector of claim 32 wherein the vector is a plasmid or a viral vector.
34. The expression vector of claim 33 wherein the viral vector is selected from the group consisting of poxvirus, adenovirus, retrovirus, herpesvirus, and adeno-associated virus.
35. The expression vector of claim 34 wherein the viral vector is a poxvirus selected from the group consisting of vaccinia, NYVAC, avipox, canarypox, ALVAC, ALVAC(2), fowlpox, and TROVAC.
36. The poxvirus of claim 35 wherein the viral vector is a poxvirus selected from the group consisting of NYVAC, ALVAC, and ALVAC(2).
37. The expression vector of claim 32 further comprising at least one nucleic acid encoding a tumor antigen.
38. The expression vector of claim 37 wherein the vector is a plasmid or a viral vector.
39. The expression vector of claim 38 wherein the viral vector is selected from the group consisting of poxvirus, adenovirus, retrovirus, herpesvirus, and adeno-associated virus.
40. The expression vector of claim 39 wherein the viral vector is a poxvirus selected from the group consisting of vaccinia, NYVAC, avipox, canarypox, ALVAC, ALVAC(2), fowlpox, and TROVAC.
41. The poxvirus of claim 40 wherein the viral vector is a poxvirus selected from the group consisting of NYVAC, ALVAC, and ALVAC(2).

42. A composition comprising an expression vector for inducing an anti-tumor immune response in a patient, said vector comprising a nucleic acid sequence encoding the angiogenesis-associated antigen AAC2-1 or AAC2-2 in a pharmaceutically acceptable carrier.
43. A composition of claim 42 wherein said vector is a plasmid or a viral vector.
44. A composition comprising an expression vector for inducing an anti-tumor immune response in a patient, the vector comprising a nucleic acid sequence encoding at least one peptide listed in Table II or III in a pharmaceutically acceptable carrier.
45. A composition comprising an expression vector for inducing an anti-tumor immune response in a patient, the vector comprising a nucleic acid sequence encoding at least one amino acid sequence selected from the group consisting of ILTDVTLLV, RLRGILTDV, and GILTDVTLL in a pharmaceutically acceptable carrier.
46. A composition of claim 45 wherein said vector is a plasmid or a viral vector.
47. A method for preventing or treating an angiogenesis-dependent disease comprising administering to a host a polypeptide having the amino acid sequence of AAC2-1 or AAC2-2 or a fragment thereof.
48. A method for preventing or treating an angiogenesis-dependent disease comprising administering to a host an expression vector encoding AAC2-1 as shown in SEQ ID NO.: 1 or a fragment thereof.
49. A method for preventing or treating an angiogenesis-dependent disease comprising administering to a host an expression vector encoding AAC2-2 as shown in SEQ ID NO.: 4 or a fragment thereof.
50. A method for treating breast cancer in a host comprising administering to the host a nucleic acid sequence encoding the amino acid sequence shown in SEQ ID NO.: 2 or SEQ ID NO.: 5.
51. A method for treating breast cancer in a host comprising administering to the host a nucleic acid sequence encoding the amino acid sequence shown in SEQ ID NO.: 1 or SEQ ID NO.: 4.
52. A method of claim 50 or 51 wherein said nucleic acid sequence is administered as a plasmid or viral vector.

53. An isolated DNA molecule comprising the sequence illustrated in SEQ ID NO.: 3.

54. An isolated DNA molecule comprising the sequence illustrated in SEQ ID NO.: 4.

55. An isolated DNA molecule encoding the amino acid sequence illustrated in SEQ ID NO. 2.

56. An isolated DNA molecule encoding the amino acid sequence illustrated in SEQ ID NO. 5.

FIGURE 1A

```
AAC2-1  ATGGGTTCCCCCGCCGCCCCGGAGGGAGCGCTGGGCTACGTCCGCGAGTTCACTCGCCACTCCT
AAC2-2  ATGGGTTCCCCCGCCGCCCCGGAGGGAGCGCTGGGCTACGTCCGCGAGTTCACTCGCCACTCCT

AAC2-1  CCGACGTGCTGGGCAACCTCAACGAGCTGCGCCTGCGCGGGGATCCTCACTGACGTCACGCTGCT
AAC2-2  CCGACGTGCTGGGCAACCTCAACGAGCTGCGCCTGCGCGGGATCCTCACTGACGTCACGCTGCT

AAC2-1  GGTTGGCGGGCAACCCCTCAGAGCACACAAGGCAGTTCTCATCGCCTGCAGTGGCTTCTTCTAT
AAC2-2  GGTTGGCGGGCAACCCCTCAGAGCACACAAGGCAGTTCTCATCGCCTGCAGTGGCTTCTTCTAT

AAC2-1  TCAATTTTCCGGGGCCGTGCGGGAGTCGGGGTGGACGTGCTCTCTCTGCCCGGGGGTCCCGAAG
AAC2-2  TCAATTTTCCGGGGCCGTGCGGGAGTCGGGGTGGACGTGCTCTCTCTGCCCGGGGGTCCCGAAG

AAC2-1  CGAGAGGCTTCGCCCCTCTATTGGACTTCATGTACACTTCGCGCCTGCGCCTCTCTCCAGCCAC
AAC2-2  CGAGAGGCTTCGCCCCTCTATTGGACTTCATGTACACTTCGCGCCTGCGCCTCTCTCCAGCCAC

AAC2-1  TGCACCAGCAGTCCTAGCGGCCGCCACCTATTTGCAGATGGAGCACGTGGTCCAGGCATGCCAC
AAC2-2  TGCACCAGCAGTCCTAGCGGCCGCCACCTATTTGCAGATGGAGCACGTGGTCCAGGCATGCCAC

AAC2-1  CGCTTCATCCAGGCCAGCTATGAACCTCTGGGCATCTCCCTGCGCCCCCTGGAAGCAGAACCCC
AAC2-2  CGCTTCATCCAGGCCAGCTATGAACCTCTGGGCATCTCCCTGCGCCCCCTGGAAGCAGAACCCC

AAC2-1  CAACACCCCCAACGGCCCCTCCACCAGGTAGTCCCAGGCGCTCGAAGGACACCCAGACCCCACC
AAC2-2  CAACACCCCCAACGGCCCCTCCACCAGGTAGTCCCAGGCGCTCGAAGGACACCCAGACCCACC

AAC2-1  TACTGAATCTCGAAGCTGCAGTCAAGGCCCCCCCAGTCCAGCCAGCCCTGACCCCAAGGCCTGC
AAC2-2  TACTGAATCTCGAAGCTGCAGTCAAGGCCCCCCCAGTCCAGCCAGCCCTGACCCCAAGGCCTGC

AAC2-1  AACTGGAAAAAGTACAAGTACATCGTGCTAAACTCTCAGGCCTCCCAAGCAGGGAGCCTGGTCG
AAC2-2  AACTGGAAAAAGTACAAGTACATCGTGCTAAACTCTCAGGCCTCCCAAGCAGGGAGCCTGGTCG

AAC2-1  GGGAGAGAAGTTCTGGTCAACCTTGCCCCCAAGCCAGGCTCCCCAGTGGAGACGAGGCCTCCAG
AAC2-2  GGGAGAGAAGTTCTGGTCAACCTTGCCCCCAAGCCAGGCTCCCCAGTGGAGACGAGGCCTCCAG

AAC2-1  CAGCAGCAGCAGCAGCAGCAGCAGCAGCAGTGAAGAAGGACCCATTCCTGGTCCCCAGAGCAGG
AAC2-2  CAGCAGCAGCAGCAGCAGCAGC***AGTGAAGAAGGACCCATTCCTGGTCCCCAGAGCAGG

AAC2-1  CTCTCTCCAACTGCTGCCACTGTGCAGTTCAAATGTGGGGCTCCAGCCAGTACCCCCTACCTCC
AAC2-2  CTCTCTCCAACTGCTGCCACTGTGCAGTTCAAATGTGGGGCTCCAGCCAGTACCCCCTACCTCC

AAC2-1  TCACATCCCAGGCTCAAGACACCTCTGGATCACCCTCTGAACGGGCTCGTCCACTACCGGGA*G
AAC2-2  TCACATCCCAGGCTCAAGACACCTCTGGATCACCCTCTGAACGGGCTCGTCCACTACCGGGAAG

AAC2-1  TGAATTTTCAGCTGCCAGAACTGTGAGGCTGTGGCAGGGTGCTCATCGGGGGCTGGACTCCTT
AAC2-2  TGAATTTTCAGCTGCCAGAACTGTGAGGCTGTGGCAGGGTGCTCATCGGGG*CTGGACTCCTT

AAC2-1  GGTTCCTGGGGACGAAGACAAACCCTATAAGTGTCAGCTGTGCCGGTCTTCGTTCCGCTACAAG
AAC2-2  GGTTCCTGGGGACGAAGACAAACCCTATAAGTGTCAGCTGTGCCGGTCTTCGTTCCGCTACAAG

AAC2-1  GGCAACCTTGCCAGTCACCGTACAGTGCACACAGGGGAAAAGCCTTACCACTGCTCAATCTGCG
AAC2-2  GGCAACCTTGCCAGTCATCGTACAGTGCACACAGGGGAAAAGCCTTACCACTGCTCAATCTGCG
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FIGURE 1A

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AAC2-1  GAGCCCGTTTTAACCGGCCAGCAAACCTGAAAACGCACAGCCGCATCCATTCGGGAGAGAAGCC
AAC2-2  GAGCCCGTTTTAACCGGCCAGCAAACCTGAAAACGCACAGCCGCATCCATTCGGGAGAGAAGCC

AAC2-1  GTATAAGTGTGAGACGTGCGGCTCGCGCTTTGTACAGGTGGCACATCTGCGGGCGCACGTGCTG
AAC2-2  GTATAAGTGTGAGACGTGCGGCTCGCGCTTTGTACAGGTGGCACATCTGCGGGCGCACGTGCTG

AAC2-1  ATCCACACCGGGGAGAAGCCCTACCCTTGCCCTACCTGCGGAACCCGCTTCCGCCACCTGCAGA
AAC2-2  ATCCACACCGGGGAGAAGCCCTACCCTTGCCCTACCTGCGGAACCCGCTTCCGCCACCTGCAGA

AAC2-1  CCCTCAAGAGCCACGTTCGCATCCACACCGGAGAGAAGCCTTACCACTGCCACCCCTGTGGCCT
AAC2-2  CCCTCAAGAGCCACGTTCGCATCCACACCGGAGAGAAGCCTTACCACTGCGACCCCTGTGGCCT

AAC2-1  GCATTTCCGGCACAAGAGTCAACTGCGGCTGCATCTGCGCCAGAAACACGGAGCTGCTACCAAC
AAC2-2  GCATTTCCGGCACAAGAGTCAACTGCGGCTGCATCTGCGCCAGAAACACGGAGCTGCTACCAAC

AAC2-1  ACCAAAGTGCACTACCACATTCTCGGGGGGCCCTAG
AAC2-2  ACCAAAGTGCACTACCACATTCTCGGGGGGCCCTAG
```

FIGURE 1B

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AAC2-1   MQSPAAPEGALGVVREPTRHSSDVLGNLNELRLRGILTDVTLLVGGQPLRAHKAVLIACSGFFYSIFRG
AAC2-2   MQSPAAPEGALGVVREPTRHSSDVLGNLNELRLRGILTDVTLLVGGQPLRAHKAVLIACSGFFYSIFRG

AAC2-1   RAGVGVDVLSLPGGPEARGFAPLLDFMYTSRLRLSPATAPAVLAAATYLQMEHVVQACHRFIQASYEPL
AAC2-2   RAGVGVDVLSLPGGPEARGFAPLLDFMYTSRLRLSPATAPAVLAAATYLQMEHVVQACHRFIQASYEPL

AAC2-1   LPGGPEARGFAPLLDFMYTSRLRLSPATAPAVLAAATYLQMEHVVQACHRFIQASYEPLGISLRPLEAE
AAC2-2   LPGGPEARGFAPLLDFMYTSRLRLSPATAPAVLAAATYLQMEHVVQACHRPIQASYEPLGISLRPLEAE

AAC2-1   PPTPPTAPPPGSPRRSEGHPDPPTESRSCSQGPPSPASPDPKACNWKKYKYIVLNSQASQAGSLVGERS
AAC2-2   PTTPPTAPPPGSPRRSEGHPDPPTESRSCSQGPPSPASPDPKACNWKKYKYIVLNSQASQAGSLVGERS

AAC2-1   SGQPCPQARLPSGDEASSSSSSSSSSSSSEEGPIPGPQSRLSPTAATVQPKCGAPASTPYLLTSQAQDTS
AAC2-2   SGQPCPQARLPSGDEASSSSSSSSSSS*EEGPIPGPQSRLSPTAATVQPKCGAPASTPYLLTSQAQDTS

AAC2-1   GSPSERARPLPGVNFSAARTVRLWQGAHRGLDSLVPGDEDKPYKCQLCRSSFRYKGNLASHKTVHTGEK
AAC2-2   GSPSERARPLPGSEFFSCQNCEAVAGCSSGLDSLVPGDEDKPYKCQLCRSSFRYKGNLASHKTVHTGEK

AAC2-1   PYHCSICGARFNRPANLKTHSRIHSGEKPYKCTCGSRFVQVAHLRAHVLIHTGEKPYPCPTCGTRFRH
AAC2-2   PYHCSICGARFNRPANLKTHSRIHSGEKPYKCTCGSRFVQVAHLRAHVLIHTGEKPYPCPTCGTRFRH

AAC2-1   LQTLKSHVRIHTGEKPYHCDPCGLHFRHKSQLRLHLRQKHGAATNTKVHYHILGGP
AAC2-2   LQTLKSHVRIHTGEKPYHCDPCGLHFRHKSQLRLHLRQKHGAATNTKVHYHILGGP
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FIGURE 2

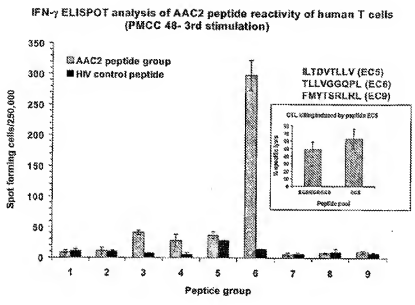

IFN-γ ELISPOT analysis of AAC2 peptide reactivity of human T cells
(PMCC 48- 3rd stimulation)
AAC2 peptide group
HIV control peptide
ILTDVTLLV (EC5)
TLLVGGQPL (EC6)
FMYTSRLKL (EC9)
CTL killing induced by peptide EC6
Peptide pool
Spot forming cells/250,000
Peptide group

FIGURE 3

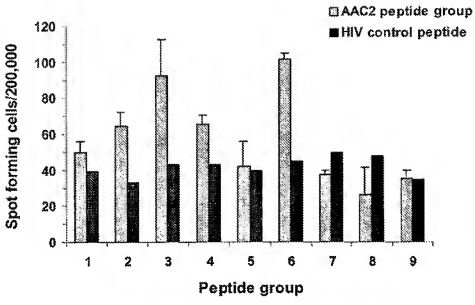

AAC2 peptide group
HIV control peptide
Spot forming cells/200,000
120
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
Peptide group

FIGURE 4

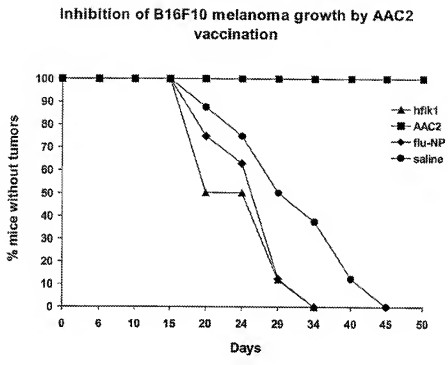

Inhibition of B16F10 melanoma growth by AAC2 vaccination
% mice without tumors
Days
hflk1
AAC2
flu-NP
saline
100
90
80
70
60
50
40
30
20
10
0
0
6
10
15
20
24
29
34
40
45
50

FIGURE 5

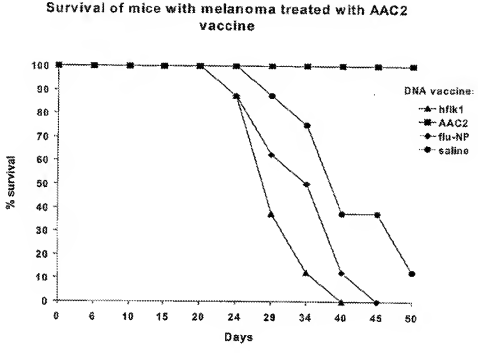
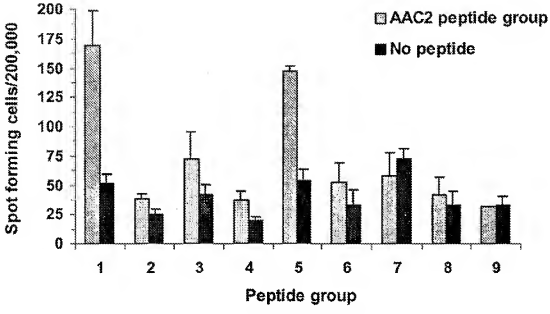

Survival of mice with melanoma treated with AAC2 vaccine
% survival
Days
DNA vaccine:
hflk1
AAC2
flu-NP
saline
100
90
80
70
60
50
40
30
20
10
0
0
6
10
15
20
24
29
34
40
45
50

FIGURE 6


AAC2 peptide group
No peptide
Spot forming cells/200,000
200
175
150
125
100
75
50
25
0
1
2
3
4
5
6
7
8
9
Peptide group

SEQUENCE LISTING

SEQ ID NO. 1: AAC2-1 nucleotide sequence

AGCAGGACCGGGGCCTGTGTCGCTATGGGTTCCCCCGCCGCCCCGGAGGGAGCGCTGGGCTACGTCCGCGAGTTCAC
TCGCCACTCCTCCGACGTGCTGGGCAACCTCAAGGAGCTGCGCCTGCGCGGGGATCCTCACTGACGTCAAGCTGCTGG
TTGGCGGGCAACCCCTCAGAGCACACAAGGCAGTTCTCATCGCCTGCAGTTGGCTTCTTCTATTCAATTTTCCGGGGC
CGTGCGGGAGTCGGGGTGGACGTGCTCTCCTCTGCCCGGGGGTCCCGAAGCGAGAGGCTTCGCCCCTCTATTGGACTT
CATGTTACACTTCGCGCCTGCGCCTCTCTCCAGCCACTGCACCAGCAGTCCTAGCGGCCGCCACCTATTTGCAGATGG
AGCACGTGTCTCAGGCATGCCACCGCTTCATCCAGGCCAGCTATGAACCTCTGTGGCATCTCCCTGGCCCCCTGGAA
GCAGAACCCCCAACCACCCCCAACGGCCCTCCACCAGGTAGTCCCAGGCGCTCCGAAGGACACCCAGACCCACCTAC
TGAATCTCGAAGCTGCAGTCAAGGCCCCCCCAGTCCAGCCAGCCCTGACCCCAAGGCCTGCAACTGGAAAAAGTACA
AGTACATCGTGCTAAACTCTCAGGCCTCCCAAGCAGGGAGCCTGGTCGGGGAGAGAAGTTCTGGTCAACCTTGCCCC
CAAGCCAGGCTCCCCAGTGGAGACGAGGCCTCCAGCAGCAGCAGCAGCAGCAGCAGCAGCAGTGAAGAAGGACC
CATTCCTGCTCCCCAGAGCAGGCTCTCTCCAACTGCTGCCACTGTGCAGTTCAAATGTGGGGCTCCAGCCAGTACCC
CCTACCTCCTCACATCCCAGGCTCAAGACACCTCTGGATCACCCTCTGAACGGGCTCGTCCACTACCGGGAGTGAAT
TTTTCAGCTGCCAGAACTGTGAGGCTGTGGCAGGGTGCTCATCGGGGGCTGGACTCCTTGGTTCCTGGGGACGAAGA
CAAACCCTATAAGTGTCAGCTGTGCCGGTCTTCGTTCCGCTACAAGGGCAACCTTGCCAGTCACCGTACAGTGCACA
CAGGGGAAAAGCCTTACCACTGCTCAATCTGCGGAGCCCGTTTTAACCGGCCAGCAAACCTGAAAACGCACAGCCGC
ATCCATTCGGGAGAGAAGCCGTATAAGTGTGAGACGTGCGGCTCGGCGTTTGTACAGGTGGCACATCTGCGGGCGCA
CGTGCTGATCCACACCGGGGAGAAGCCCTACCCTTGCCCTACCTGCGGAACCCGCTTCCGCCACCTGCAGACCCTCA
AGAGCCAGTTCGCATCCACACCGGAGAGAAGCCTTACCACTGCGACCCCTGTGGCCTGCATTTCGGCACAGAGAGT
CAACTGCGGCTGCATCTGCGCCAGAAACACGGAGCTGCTACCAACACCAAAGTGCACTACCACATTCTCGGGGGGCC
CTAGCTGAGCGCAGGCCCAGGCCCCACTTGCGTCCCTGCGGGTGGCAAAGCTGCACGCCCAGGCCTTGCTTCCCTATC
AGGCTTGGGCATAGGGGTGTGCCAGGCCACTTTGGTATCAGAAATTGCCACCCTCTTAATTTCTCACTGGGGAGAGC
AGGGGTGGCAGATCCTGGCTAGATCTGCCTCTGTTTTGCTGGTCAACCCCTTCCCACAAGCAGATTGTTCCTG
AGGAGAGAGCTAGCTAGGGGCTGGGAAAGGGGAGAGATTGGAGTCCTGGTCTCCCTAAGGAATAGCCCTCCACCTG
TGGCCCCATTGCATTCAGTTTATCTGTAAAATATAATTTATTGAGGCCTTTGGGTGGCACCGGGGGCTTCATTCGA
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TGGCACGAGATTACTAGCCTTGGCTCTCTCGTTTGGCTGGGTATTTTATATTATTTCTGTCATAACTTTTATCTTT
AGAATTGTTCTTTCTCCTGTTTGTTTGCTTGTTAGTTTGTTTAAAATGGAAAAAGGGGTTCTCTGTGTCTGCCCCT
GTAATTCTAGGTCTGGAACCTTTATTTGTTCTAGGGCAGCTCTGGGAACATGCGGGATTGTGGAATTGGCTCAGGAA
CCCTCCTCTGGTATTCTGGATGTTGTAGGTTCTCTAGCAGTCTAGAAATGGATACAGACATTTCTCTGTTCTTCAAG
GTGATAGGAACCATTATGTTGAGCCCAAAATGGAAGTAATAATAAATGCCTCCTGGAGGCTGTGGGTGTGGGGATT
CTGTATCTGGATTCCGTATCACTCCAACTGCGAGGCTGTGGGTGTGGGGGATTCTGTATCTGGATTCCGTATCACTCC
AAGTGGAGCGTGGCAGTTTTCTGCAAGATGGTCCAGAATCTAAAATGTCCCATTAATCTGGTCACTTGGGTTTGG
CTCTGCTGTATCCATCTATAGTGGTAGAGACCCACCAGGGCTCAAGTGGAGTCATCATCCTCCCACGGGGCCCTGT
TCTTAGTACTGAGTTGATCGCTCCATGGGGAGAGAGATCAGACATCCTTATCAGAGATGATGTGACCTTTTCTGACT
CTGCCCAGTCCTATGAATGTTATGGCCTAGCGAGAGAATCATGAAACTCTTTTAGCTTGATTAGATGGTAAACAGTGT
TAACCCATCCTTACTACAGAGGCATATGGGTTGAATGTTACCTGGGGTTCTCTCTATTGAGTTGAGTCCCCTTCTT
CCTTTAGTGGGTTTTGGACTCTTCTGGCAAGTGTCCAGATGCCAGAACCTTCTTTTGCTCTAGAAGGGATGGTGCT
TGGTAACCTTACCTTTTAAAAGCTGGGTCTGTGACCTGGCCTTCCCATCCCTGCTCTGCTGGAAACCAGTGAAT
GCATTGAAACCTTCCATAGGAAAAGAAAAGGGGCTGAGTTCCATTCTGGGTTTGCTGTAGTTTGGTTGGGATTATTG
TTGGCATTACAGATGTAAAAGATTGACTAGCCCATAGGCCAAAGGCCTGTTCTAGTTGACCAAGTTTCAAGTAGGAT
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CTAGTGGCTGTCGCCTGGGGACTAGTGACAAAGCTACTCTTCTCCCTCTTCCCTCTTTCTCCCCATGGCCCCACTGC
AGAATTAAAGAAGCGAAGAAGGGAAGGCGGAGGAGTCTATAAGAAGGAATCATGATTTCTATTTAGCAGATTGGATTG
GCAGGTGGAGAATGCCTGGGGGTAGAAATGTTAGATCTTGCAACATCAGATCCTTGGAATAAAGAAGCCTCTCTGCG
CAAAAAAAAAAAAAAAAAAAAA

SEQ ID NO. 2: AAC2-1 amino acid sequence

MGSPAAPEGALGYVREFTRHSSDVLGNLNELRLRGILTDVTLLVGGQPLRAHKAVLIACSGFPYSIPRGRAGVGVDV
LSLPGGPEARGFAPLLDPMYTSRLRLSPATAPAVLAANTYLQMEHVVQACHRFIQASYEPLGISLRPLEAEPPTPPT
APPPGSPRRSEGHPDPPTESRSCSQGPPSPASPDPKACNWKKVKYIVLNSQASQAGSLVGERSSGQPCPQARLPSGD
EASSSSSSSSSSSSEEGPIPGPQSRLSPTAATVQFKCGAPASTPYLLTSQACDTSGSPESRARPLPGVNFSAARTVR
LWQGAHRGLDSLVPGDEDKPYKCQLCRSSFRYKGNLASHRTVHTGEKPYHCSICGARFNRPANLKTHSRIHSGEKPY
KCETCGSRFVQVAHLRAHVLIHTGEKPYPCPTCGTRFRHLQTLKSHVRIHTGEKPYHCDPCGLHFRHKSQLRLHLRQ
KHGAATNTKVHYHILGGP

SEQ ID NO. 3: AAC2-2 nucleotide sequence

TCTGCGTGTGCCGGGGCTAGGGGCTGGAAGTCCTGGCTCTAGTTGCACCTCGGAAGGAAAAGGCAAACAGAGGAGGGAAGGCGTCT
TAGGACTGCCTGGATCCAGAGCACTTTCCTCGGCCTCTACAGGCCTGTGTGGCTATGGGTTCCCCGCCCGCCCCGGAGGGAGCGCT
GGGCTACGTCCGGAGTTCACTGCCACACTCCTCCGACGTGCTGGGCAACCTCAACGAGCTGCCCCTGCGCGGGATCCTCACTGACG
TCACGCTGCTGGTTGGCGGGCAACCCCTCAGAGCACACAAGGCAGTTCTCATCGCCTGCAGTGGCTTCTTCTATTCAATTTTCCGG
GGCCGTGCGGGAGTCGGGGTGGACGTGCTCTCTCTGCCGGGGGTCCGAAGCGAGAGGCTTCGCCCCTCTATTGGACTTCAGTTA
CACTTCGCGCCTGCGCCTTCTCCAGCCACTGCACCAGCAGTCCTAGCGGCCGCCACCTATTTGCAGATGGAGCACGTGGTCCAGG
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GCCCCTCCACCAGGTAGTCCCGAGGCGCTCGGAAGGACACCGAGACCCACCTACTGAATCTCGGAAGCTGCAGTCAAGGCCCCCGAG
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TTGATCGCTCCATCGATGGGGGAGAGATCAGACATTCCTATCAGNAGATGATGACCTTTCTGACTCTGCCCAGTCCTATAGATGTT
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GGCACTAGTGAAGAAGCTACTCTTTCCCCTCTTCCCCATTGCCCCACTGCAGAATTAAAGRAAGGAAGGAAGGAAGG
CGGAGGAGTCTATAAGAAACGAATCATGATTTCTATTTAGCAGATTGGATGGGCAGGTGGAGAATGCCTGGGGGTAGAAATGTTAGA
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SEQ ID NO. 4: AAC2-2 open reading frame

ATGGGTTCCCCCGCCGCCCCGGAGGGAGCGCTGGGCTACGTCCGCGAGTTCACTGCCACTCCTCCGAACGTGCTGGCAACCTCAA
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CCTGCAGTGGCTTCTTCTATTCAATTTTCCGGGGCCGTGCGGGAGTCGGGGTGGACGTGCTCTCTCTGCCCGGGGGTCCGAAGCG
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CACCTATTTGCAGATGAAGCACGTGGTCCAGGCATGCCACCGCTCATCCAGCCAGCTATGAACCTCTGGCATCTCCCTGCGCC
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GAATCTGPAGTTGCAGTCAAGGCCCCCCAGTCCAGCCAGCCTCACCCCAAGCCTGCAACTGGAAAAGTACAGTACATCGT
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ACTGCTGCCACTGTGCAGTTCAAATGTGGGCTCCAGCCAGTACCCCTACCTCCTCACATCCCAGCCTCAAGACACCTCTGGATC
ACCCTCNGAACGGGCTCGTCCACTACCGGGAAGTGAATTTTCAGCTGCCAGAACTGTGAGGCTGTGCGAGGGTGCTCATCGGGGC
TGGACTCCTTGGTTCCTGGGCACGAAGACAAACCCTATAAGTGTCAGCTGTGCCGGTCTTCGTCCGCTACAAGGGCAACCTTGCC
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GCACAGCCGCATCCATTCGGGAGAGAAGCCGTATAAGTGTGAGACGTGCGGCTCGCGCTTTGTACAGTGGCACATCTGCGGGCGC
ACGTGCTGATCCAGACCGGGGAGAAGCCTACCCTTGCCCTACCTGCGGAACCCGCTTCCGCCACCTGCAGACCTCAAGAGCCAC
GTTCGCATCCACACGTAGAGAAGCCTTACCACTGCGACCCTGTGGCCTGCATTTCCGGCACAAGAGTCAACTGCGGCTCCATCT
GCGCCGAAACACGGAGCTGCTACCAACACCAAAGTGCACTACCACATTCTCGGGGGCCCTAG

SEQ ID NO. 5: AAC2-2 amino acid sequence

MGSPAAPEGALGYVREPTRHSSDVLGNLNELRLRGILTDVTLLVGGQPLRAHKAVLIACSGFFYSIFRGRAGVGVDVLSLPGGPEA
RGFAPLLDFMYTSRLRLSPATAPAVLAAAFYLQNEHVVQACHRFIQASYEPLGISLRPLEAEPPTPFTAPPPGSPRRSRGHPDPPT
RSRSCSQGPPSPASPDPKACNWKKYKYIVLNSQASQAGSLVGERSSGQPCPQARLPSGDEASSSSSSSSSSEEGPIPGPQSRLSP
TAATVQFKCGAPASTFYLLTSQAQDTGGSPSERRARLPGSEFFSCQNCEAVAGCSSGLDSLVFGDSDKPYKQLCRSSFRYEGNLA
SHRTVHTGEKPYHCSICGRAFNNPAMLKTHSRTHSGEKPYKCETCGSRFVQVAHLRAHVLIHTGEKPYPCFTCGTRFRHLQTLKSH
VRIHTGEKPYHCDPCGLHFRHKSQLRLHLRQKHGAATTEVHYHLLGGP

SEQ ID NO. 6: AAC2-2 FORWARD PRIMER

CACCATGGGT TCCCCCGCCG CCCCGGA

SEQ ID NO. 7: AAC2-2 REVERSE PRIMER

CTAGGGCCCC CCGAGAATGT GGTAGTGCAC TTT